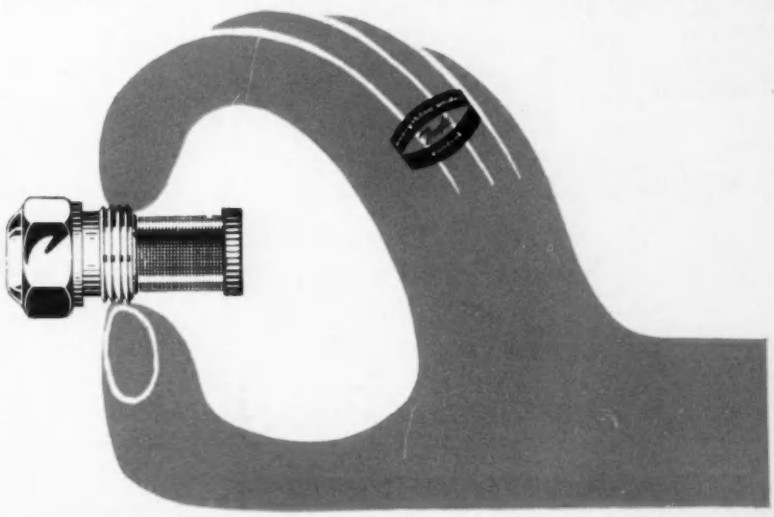
ENGINEERING AND
BOILER HOUSE REVIEW

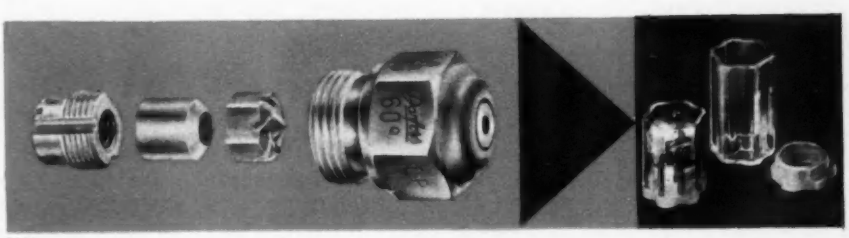
ESTABLISHED 1899

TWO SHILLINGS & SIXPENCE

VOL. 75 NO. 7 • THE PIONEER STEAM JOURNAL • JULY, 1960

A Danfoss
OIL NOZZLE
saves both user
and service engineer
a lot of trouble





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Type OD for high-pressure oil burners and Type 30D for low-pressure burners— are nozzles you can depend on !

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3 Their third service is after sales—a team of Lockheed Engineers keeps your installation up to concert pitch, and if required attends at any time anywhere. All Lockheed systems carry one year's free service.

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Recently a customer asked us if we would buy back his stock pool of spares for the Lockheed equipment in his gas plant. After 15 years' experience of our equipment and our service he had decided it was unnecessary.

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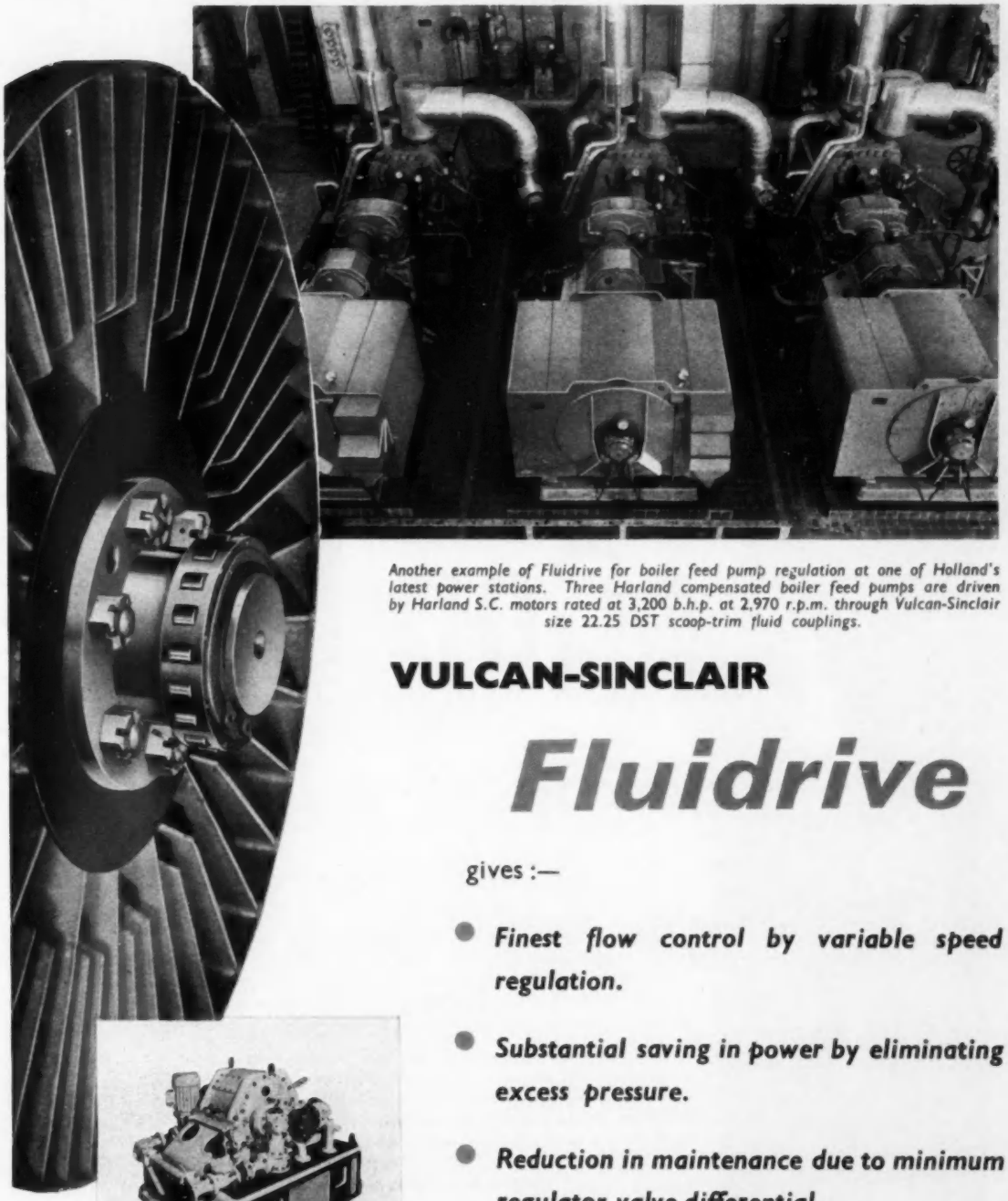

Another example of Fluidrive for boiler feed pump regulation at one of Holland's latest power stations. Three Harland compensated boiler feed pumps are driven by Harland S.C. motors rated at 3,200 b.h.p. at 2,970 r.p.m. through Vulcan-Sinclair size 22.25 DST scoop-trim fluid couplings.

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gives :—

- ***Finest flow control by variable speed regulation.***
- ***Substantial saving in power by eliminating excess pressure.***
- ***Reduction in maintenance due to minimum regulator valve differential.***

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A PLESSIFLEX application on the Bristol Bloodhound

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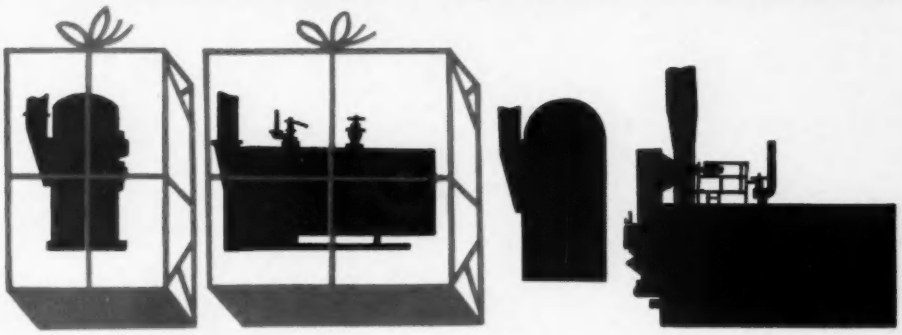

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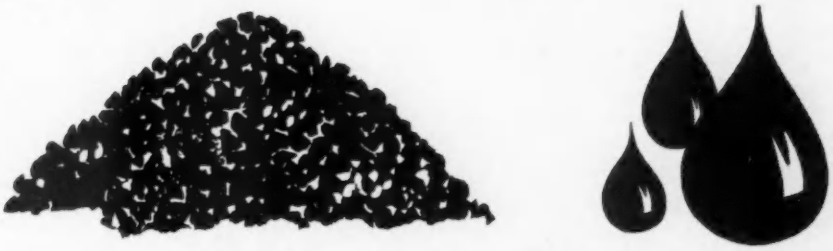

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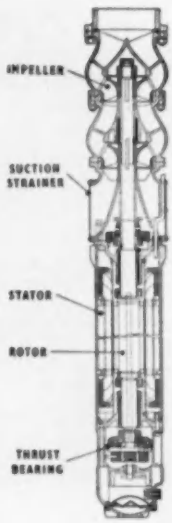
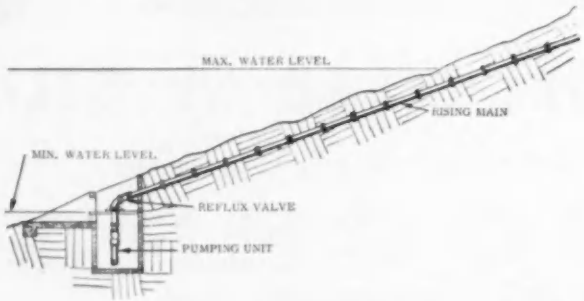
Our Patent Norias or Bucket Pumps
are the simplest machines as well as the most efficient . . .
raising considerably more water for the power applied
than any other form of pump."

But hold your horses! Send no money yet!
That was 1896. In 1960 horses are not quite hip.
Get out of the saddle and into the groove
with Hayward Tyler Electromersible Irrigation pumps.
Seats are not provided —
not even for squares who still await the message . . . .





Our diagram shows how easy it is to install Hayward Tyler Submersible Electric Irrigation Pumps. These pumps eliminate all worry about flooded motors in the Clare Irrigation Scheme, North Queensland, where the Burdekin River rises 50ft. in the wet season. Each of these units delivers 4,150 I.G.P.M. against a total head of 86 feet, but our range covers almost any quantity from 300 I.G.P.M. upwards.

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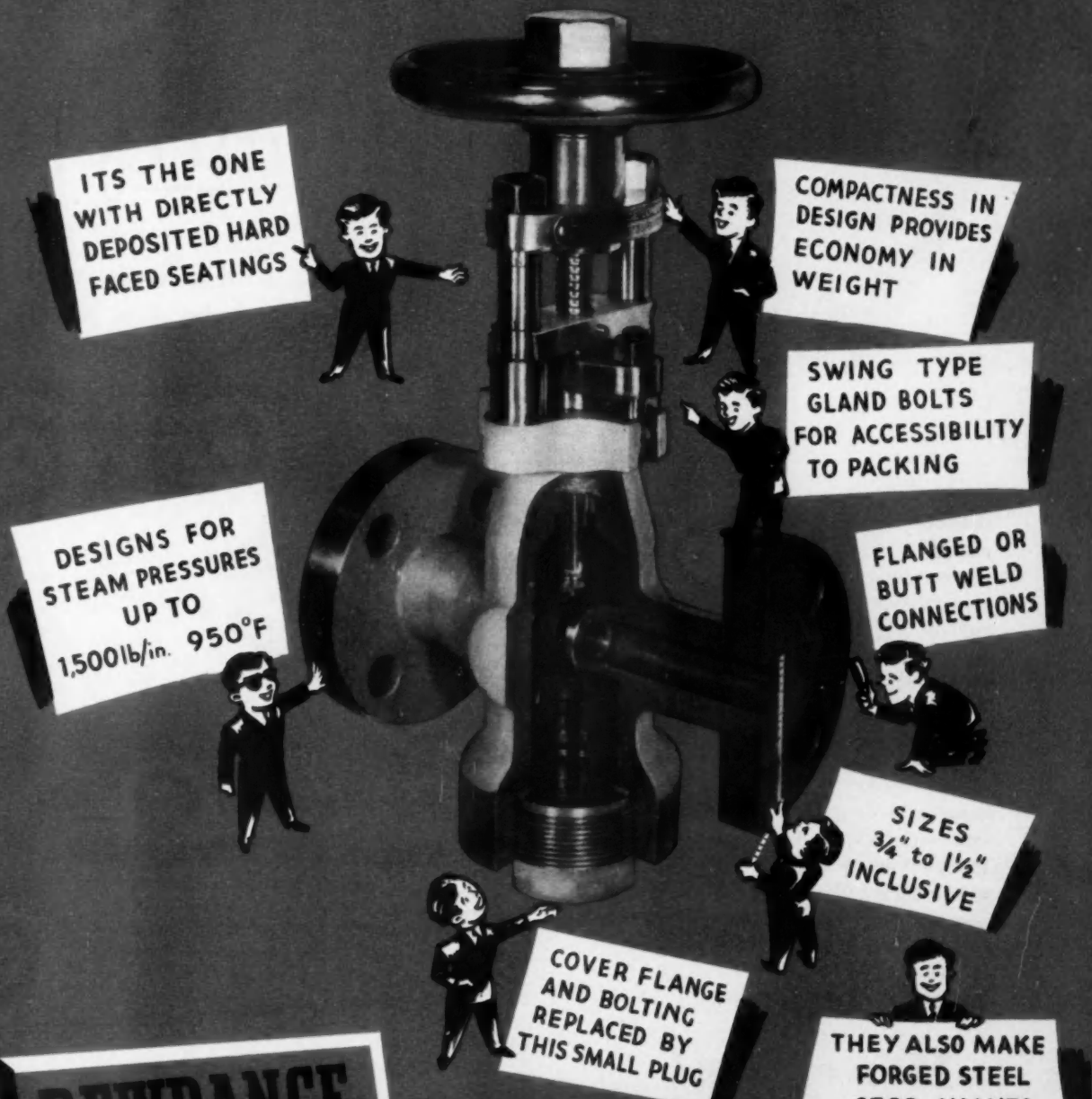
Mr. Urge and Mr. Surge remind you that Hayward Tyler make Borehole Pumps, Oil Refinery Pumps, Oil Cargo Pumps, Chemical Pumps, Glandless Pumps and Steam Turbines

For the most severe service conditions

Install **DEWRANCE** **FABRICATED PARALLEL SLIDE VALVES**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SIZES 3/4" to 1½" INCLUSIVE
COVER FLANGE AND BOLTING REPLACED BY THIS SMALL PLUG
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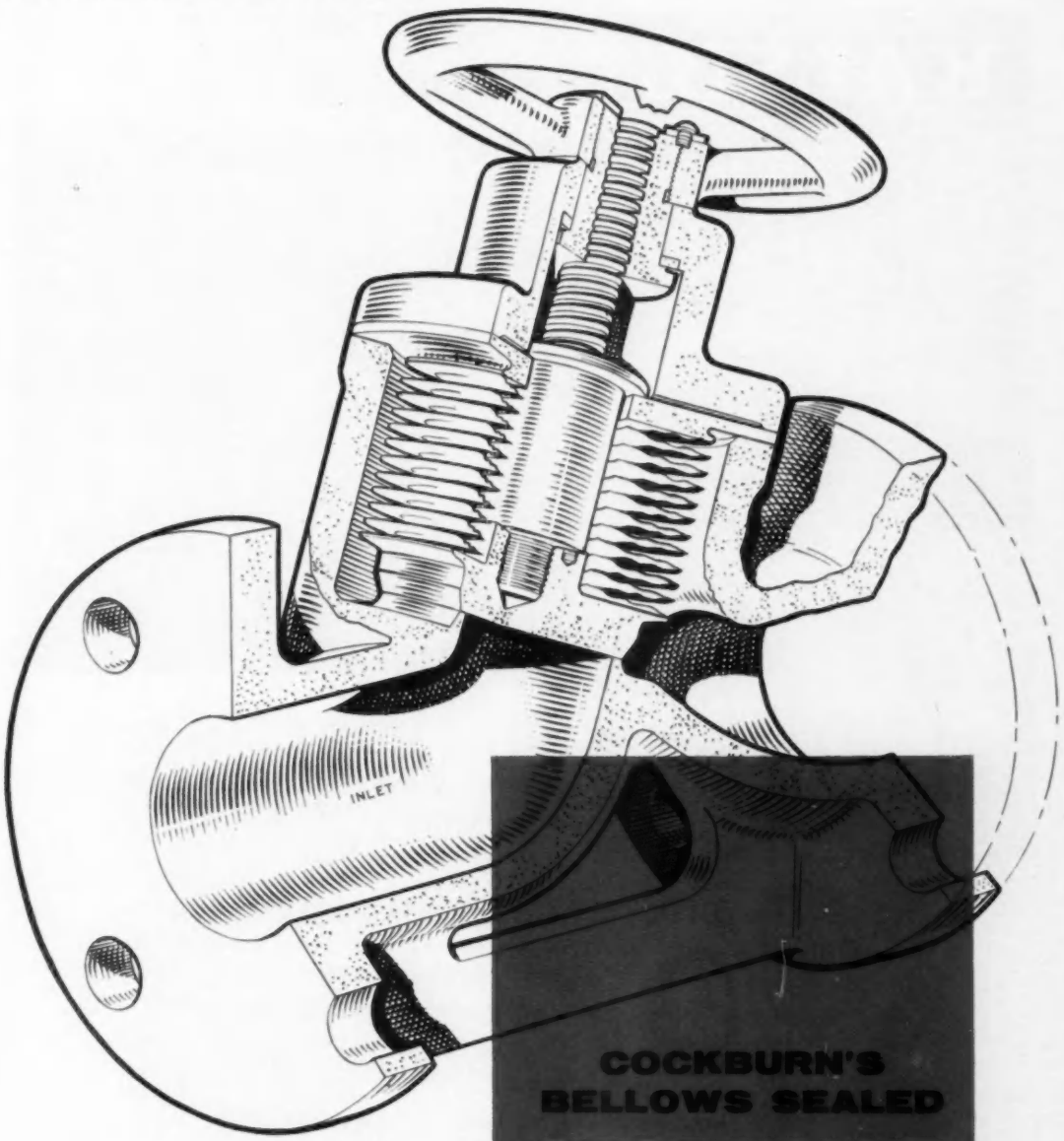

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STOP VALVE

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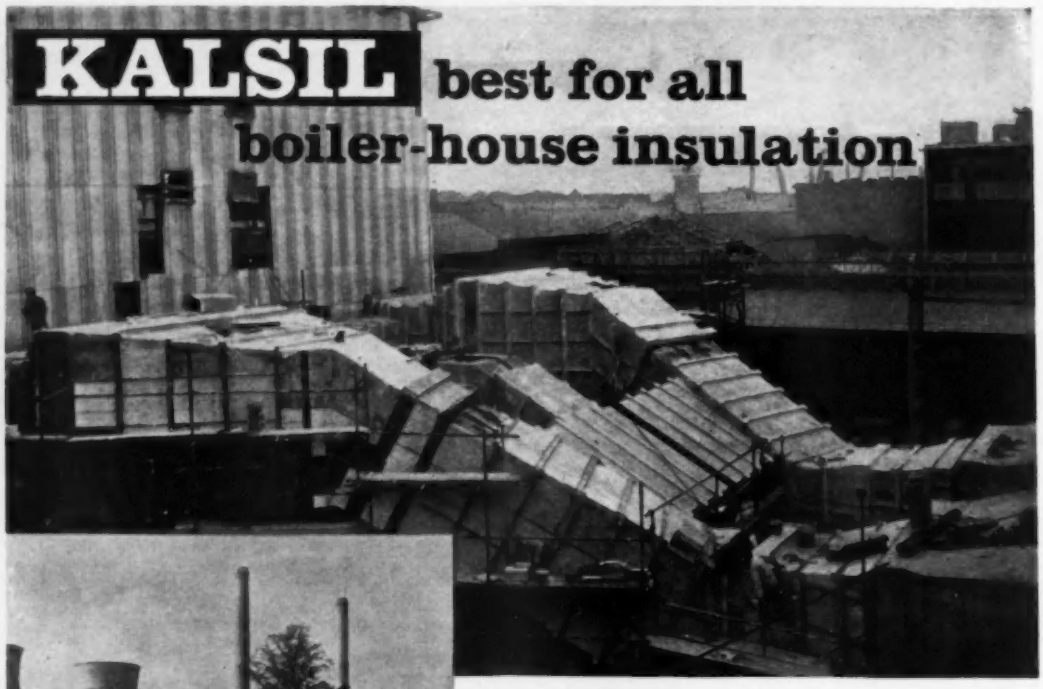
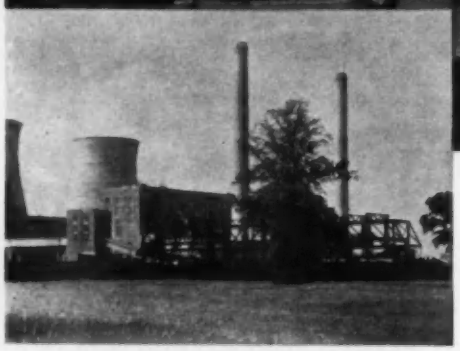
KALSIL best for all boiler-house insulation





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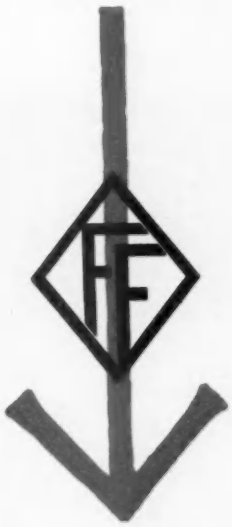

We are pleased to announce

the successful completion of the Coal to Oil Conversion of four boilers at Portishead "B" Power Station which we were privileged to instal through Messrs. Mitchell Engineering Limited with the collaboration of the Central Electricity Generating Board. This culminates nine years' previous experience exclusively in Power Station Furnaces throughout the country. Our specialised knowledge is readily available in the two types of F.F. Initiators. These auxiliary units have the triple purpose of raising pressure, coal ignition and automatic stabilising of the pulverised fuel flame. *They are absolutely essential to two-shift working to achieve the elimination of stack emission.*

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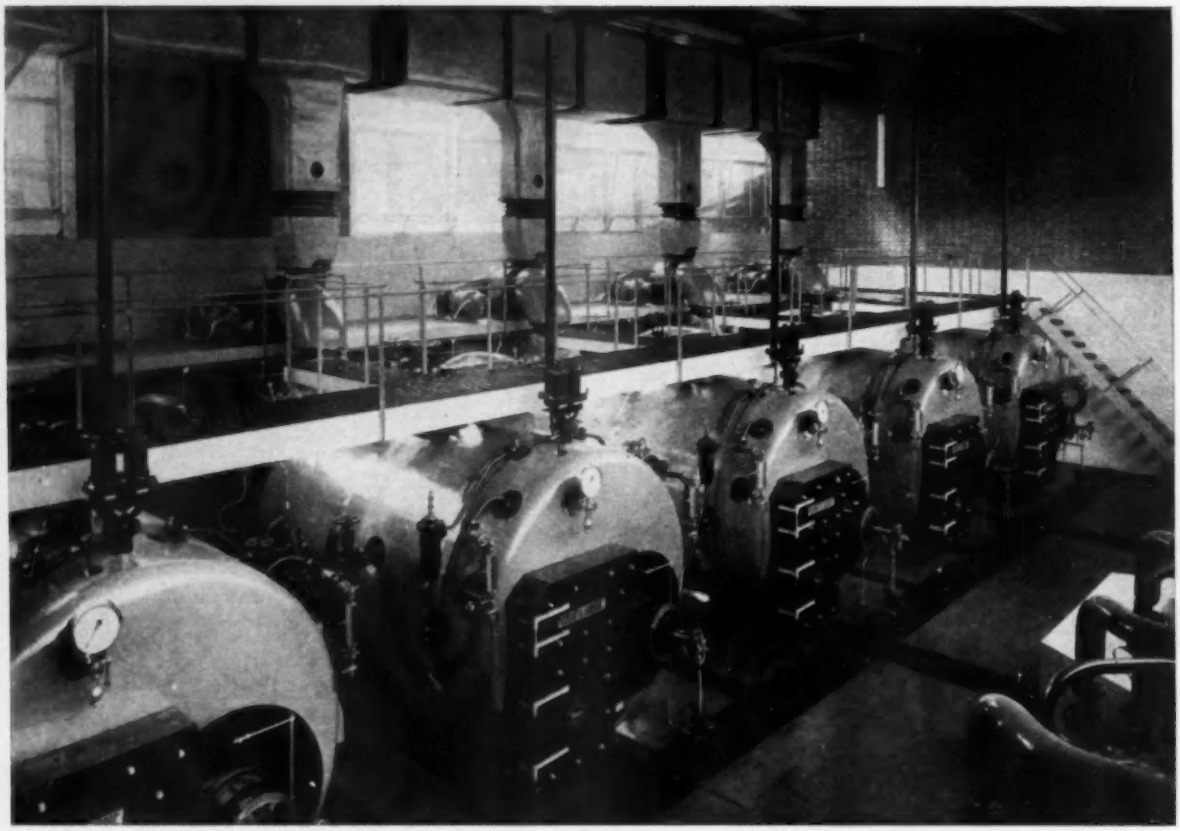

Photograph by courtesy of Davey, Paxman & Co. Ltd.

Changing conditions in Industry today call for new materials and new techniques in the field of insulation.

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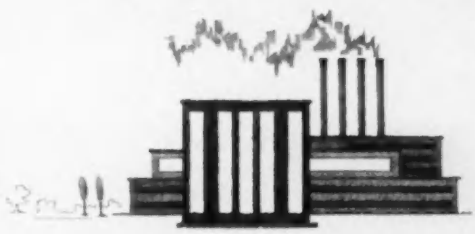
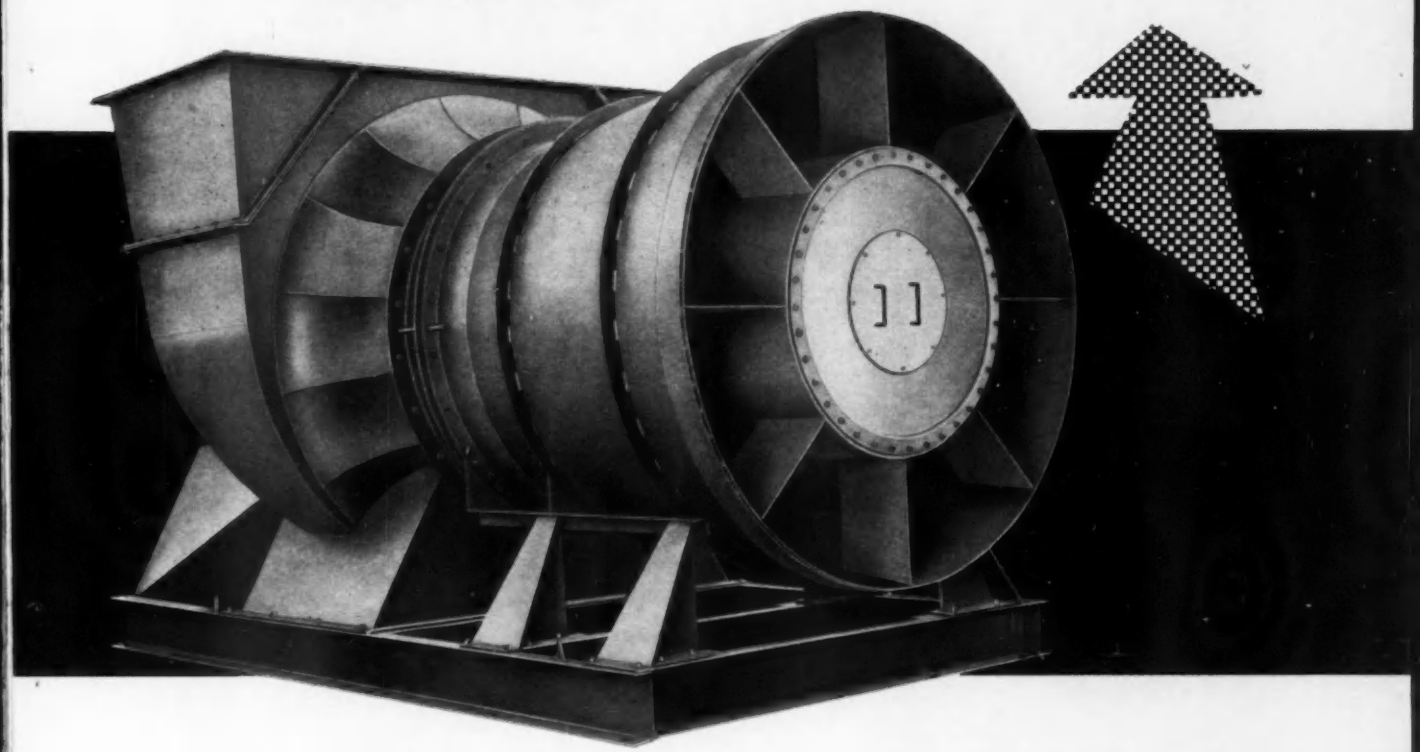


the controllable
axial flow fan



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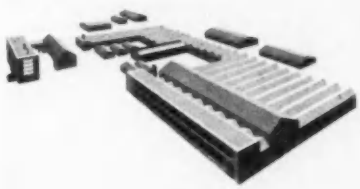

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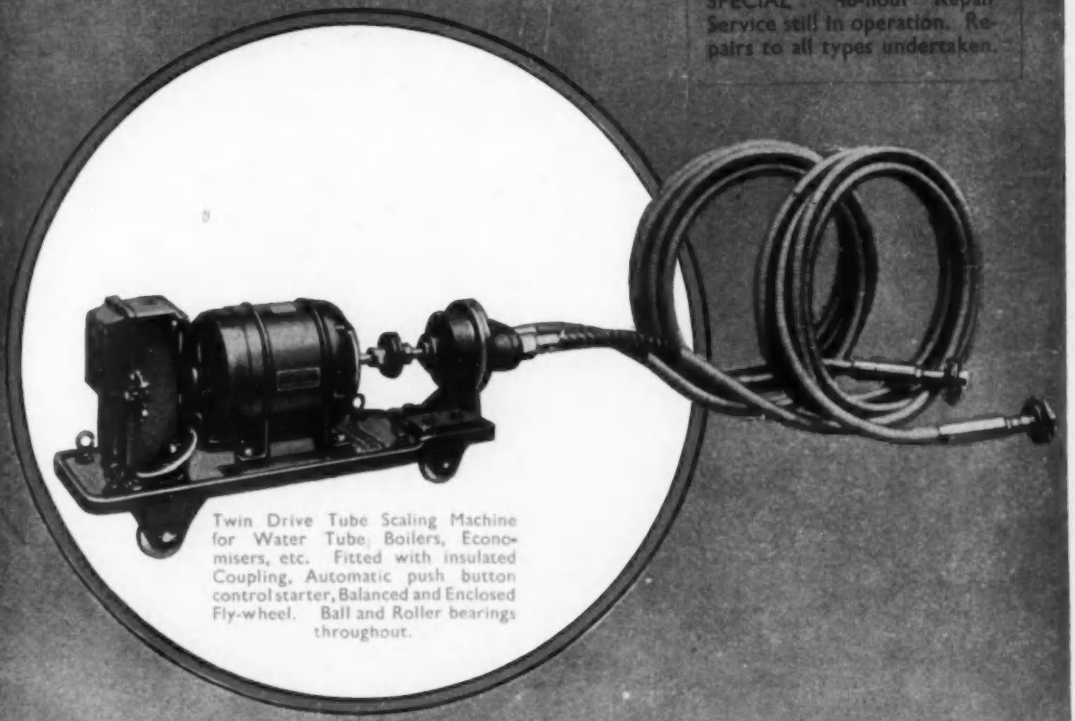

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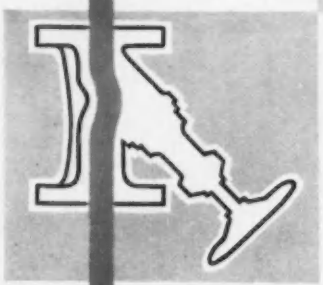

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Notable features of design.

1. Cast gun metal body and cover for strength and corrosion resistance.
2. Heavy construction with strengthening ribs scientifically designed to distribute stresses away from the shut-off zone.
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7. New Design Handwheel for comfortable and effective operation.
8. Available with Double Regulating Device for proportionate control of flow at all settings.
9. **Fig 1200 also suitable as a general purpose Steam Stop Valve.**

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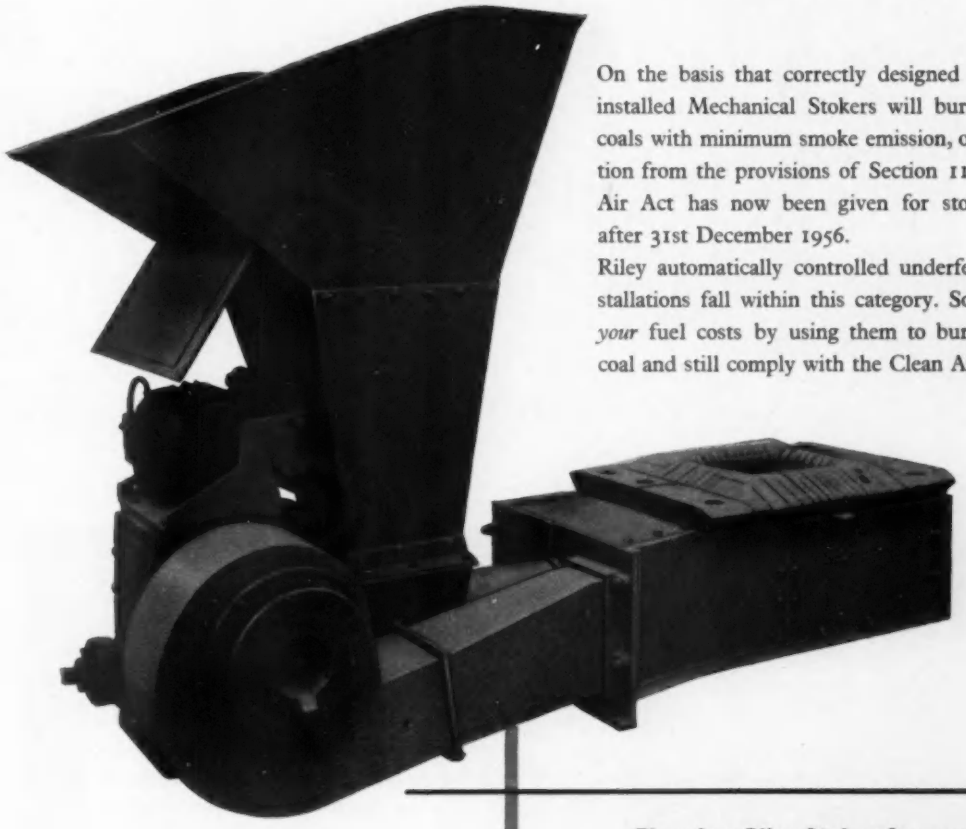

On the basis that correctly designed and properly installed Mechanical Stokers will burn bituminous coals with minimum smoke emission, official exemption from the provisions of Section 11 of the Clean Air Act has now been given for stokers installed after 31st December 1956.

Riley automatically controlled underfeed stoker installations fall within this category. So why not cut *your* fuel costs by using them to burn bituminous coal and still comply with the Clean Air Act.

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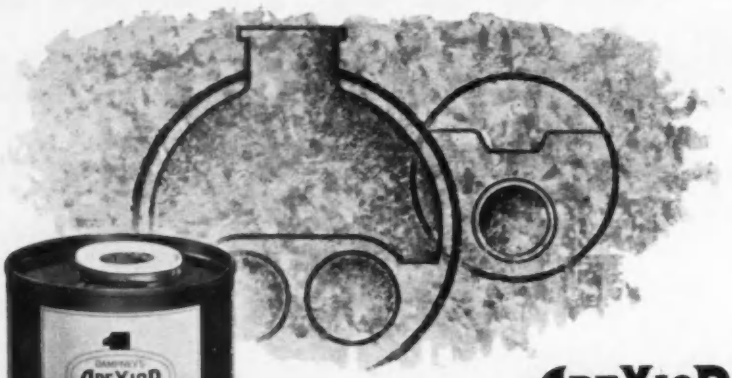

Between you and Boiler Corrosion . . .

An impenetrable shield of APEXIOR REGISTERED No. 1

On guard, and constantly ready to fight against corrosion in boilers or steam raising plant is Apexior No. 1.

Applied as a thin film to surfaces which encounter water or steam temperatures between 170°—1000° F., Apexior No. 1 is an effective, low cost protection for expensive boiler plant. It cuts corrosion to an absolute minimum; reduces scale formation. Any scale which forms can be easily and speedily removed without danger of damage to plant as it is non-adherent.

Other advantages come with Apexior No. 1: heat transmission is improved: and since Apexior is an inert coating, feed water is left completely free from discolouration or contamination. Keep step with industry to-day—be boiler wise and Apexiorise.

For full information on all aspects of Apexior No. 1 write for Booklet "Preventing Boiler Corrosion".

BPL/14/60

BRITISH PAINTS LIMITED Apexior Division

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STEEL PLATFORM GANGWAYS
ACCESS LADDERS
STAIRWAYS & BRIDGING
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Illustration by courtesy of S. SMITH & SONS (ENGLAND) LTD. shows work carried out by F. A. NORRIS & CO. LTD. at the Boiler House of their factory at Witney.

GET IN TOUCH WITH

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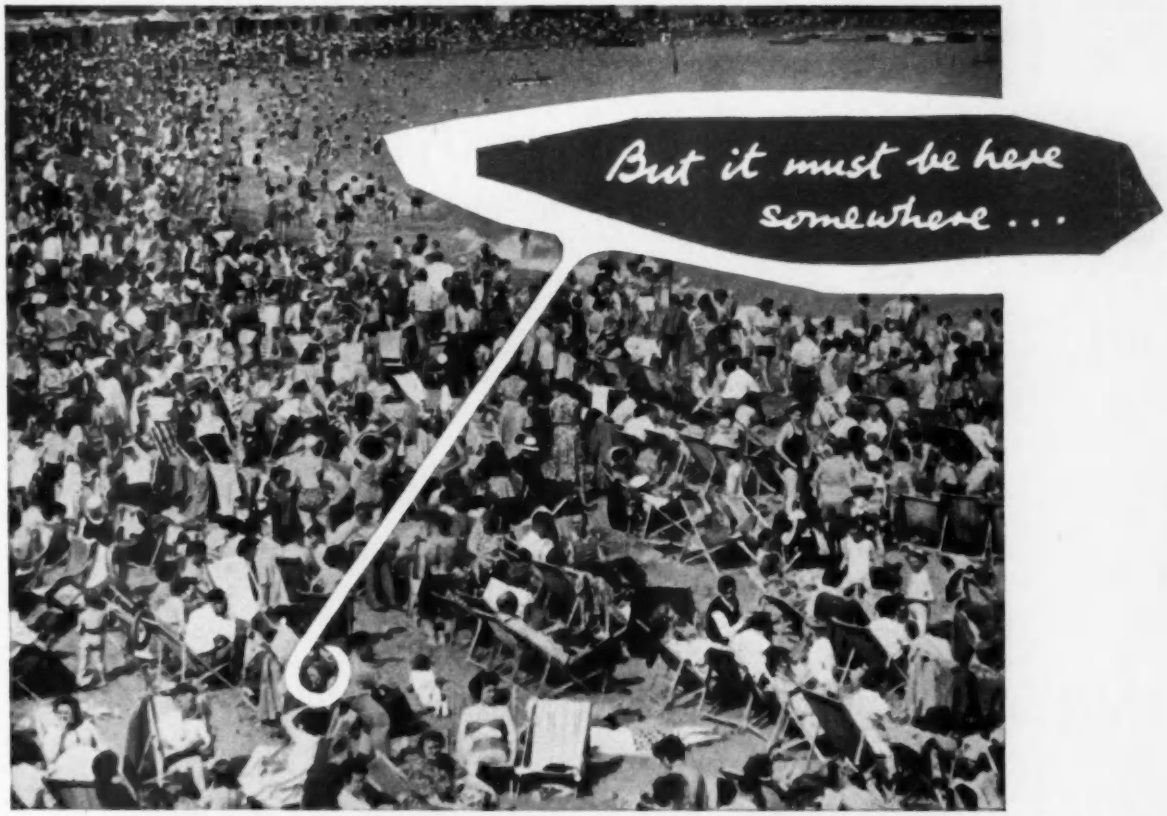

Just the spot, a holiday beach, for a quiet unflustered game of find-Mum's-knitting, where's-Dad's-pipe and have-we-got-all-the-kids. Makes you glad you're not back in the works doing annual maintenance. . . .

But it depends on your attitude. Some engineers get a real kick out of their yearly shut-down clean sweep. There's almost an explorer's thrill in rediscovering just how much muck the pipe-strainers on your steam lines have collected. Bits of scale and rust, jointing material, scraps of wire, even (in our experience) buttons and collar studs—all sorts of rubbish which can stop steam traps and control valves working properly.

Damaging they can be, too, these bits and bobs if slammed against delicate instruments on the line at high steam velocity. Prevention of damage alone is worth the cost of strainers, quite apart from their contribution to sound steam engineering.

Of course, if you don't ever use pipe-strainers, then you don't need to clean their screens regularly. But in that case, what you *do* need to do is send for our pipe-strainers pamphlet here and now, and start saving yourself a whole heap of trouble all the year round.

SPIRAX - SARCO

Please send a copy of Pamphlet No. 70 describing Spirax pipe-strainers—and perhaps a copy of Information Sheet No. 16 "Steam Distribution" which will be timely technical reading.

NAME

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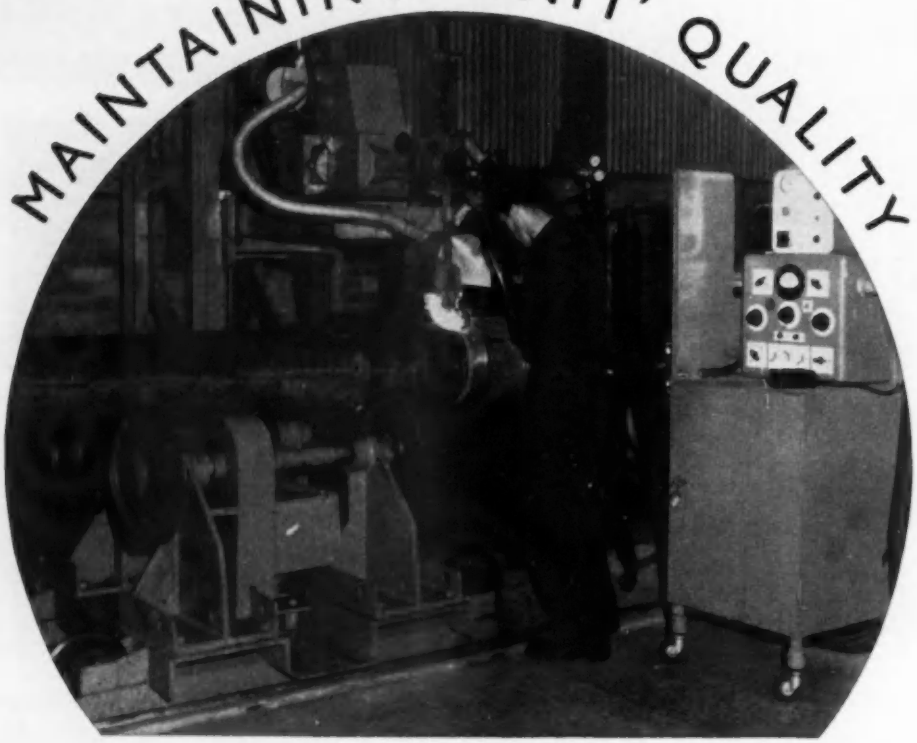
SPIRAX-SARCO LTD. CHELTENHAM PHONE 5173 GRAMS SPIRAX TELEX CHELTENHAM LONDON: 41 CURZON STREET, W.1 GROSVENOR 1671

MAINTAINING 'UNIT' QUALITY



UNIT tubular welded fabrications, for high or low pressures for industrial plants, are produced with specialized equipment—thereby maintaining the maximum standard of quality.

Illustrated is our latest Fusarc CO_2 automatic installation welding a circumferential butt joint on a reactor standpipe for Bradwell power station. The welds are one hundred per cent radiographed to a high standard of acceptance and are subject to the survey of Lloyds Register of Shipping.

'Unit' specialities include water-wall headers, steam and oil receivers, de-superheater bodies and tubular products of all descriptions for every kind of power station and for industrial steam raising plants.

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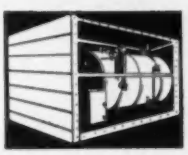
By Babcock!

STEAMBLOC the best packaged boiler

And no wonder! Only Steambloc automatic packaged boilers are backed by such vast technical and research facilities. These are provided by the Babcock & Wilcox organisation, acknowledged world leaders in boiler-making.



Steambloc boilers pack many **exclusive** *features:*

- burn heaviest oils without major modifications
- quick and simple changeover to manual operation
- longer boiler shell eliminates overheating of rear tube plate, allows greater flexibility
- patent twin rear door gives easier access
- quick-release clear-out port at bottom of front gas pass
- spill type pressure oil burner with no moving parts

Steambloc boilers are available with capacities up to 25,000 lb/hr. in two pressure ranges—up to 145 and up to 245 p.s.i.

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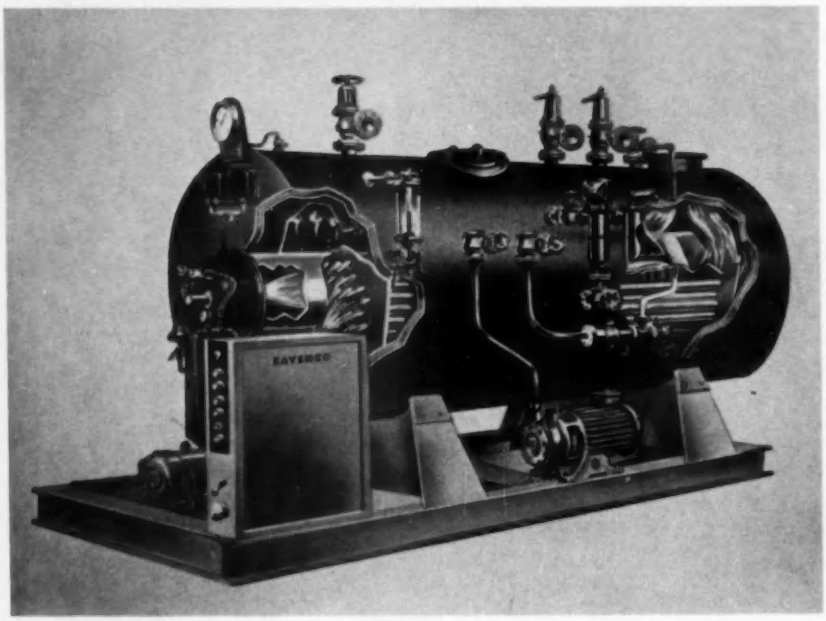
SBC

SBC8a

KAYENCO STEAM RAISING PLANT



Typical KAYENCO three pass Class I packed boiler. NOTE : *M.P.A. Burner with control cabinet. Twin Mobrey controls. Worthington Simpson feed pump. Corrugated furnace and substantial flanged mountings.*

The latest Kayenco development is a range of shell type boilers with capacities from 1,000 to 10,000 lbs. of steam per hour using gas or oil firing. KAYENCO Boilers have been thoroughly tested and proved for economy and reliability and are constructed to A.O.T.C. requirements Class I. Write for details of these new boilers and our engineers will be glad to advise you on any heating problems using gas or oil fuel and waste heat recovery.

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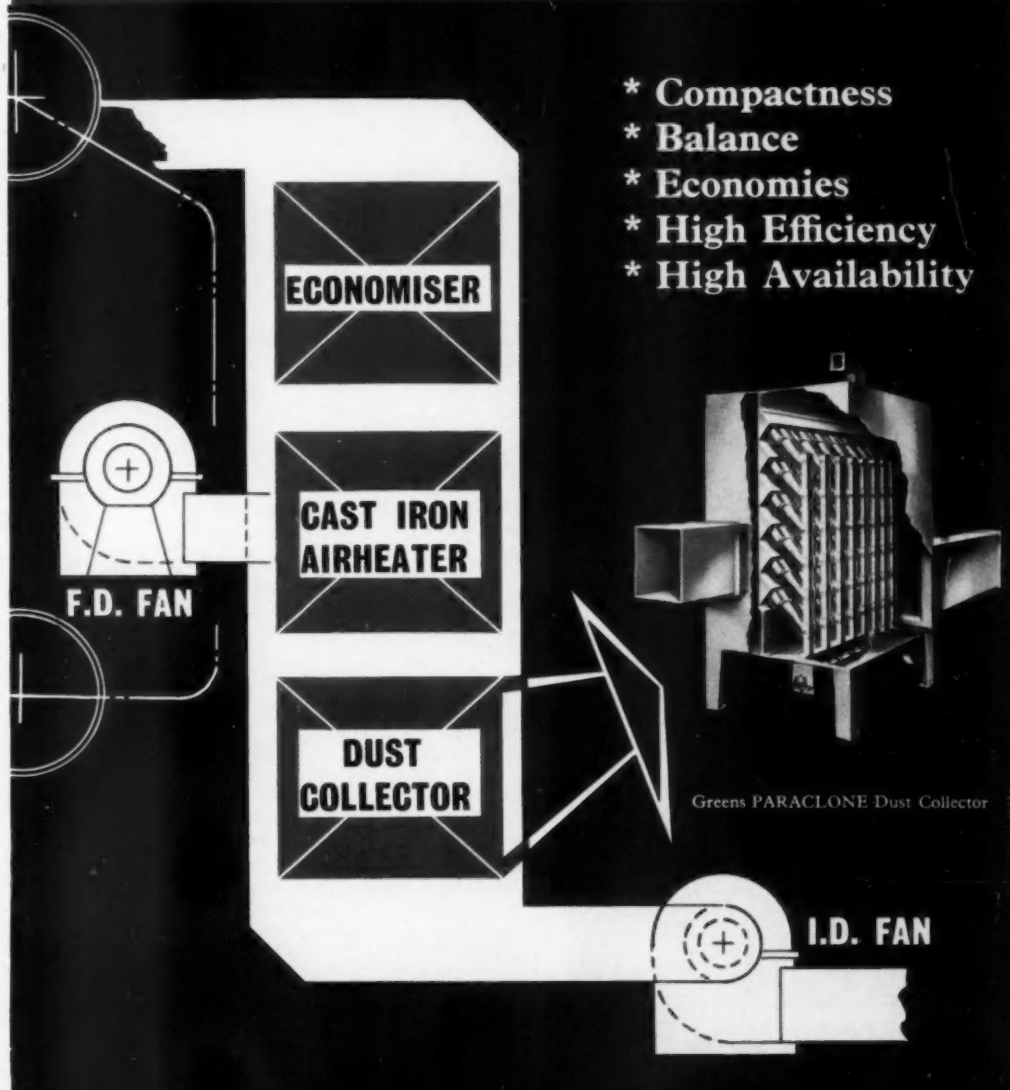

Greens PARACLONE Dust Collector

Made and supplied by the makers of the world famous Green Economiser

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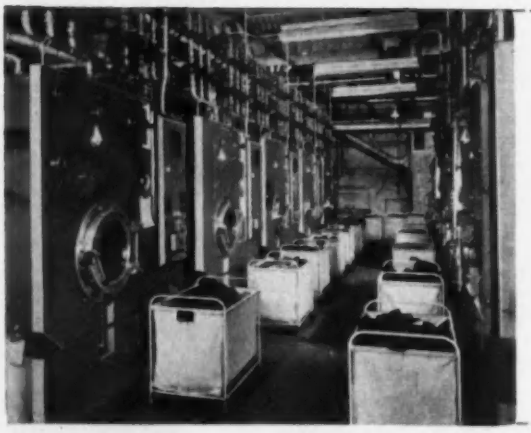
ONCE AGAIN

VALVES
BY CRANE



At the Walthamstow works of Achille Serre Ltd., the famous dry cleaners, all equipment is being completely modernised. The latest installation is a Perchlorethylene Plant, fully automatic in operation and one of the most up-to-date in the country.

As you would expect, the valves are Crane. In a works of this nature the reliability of the valves is of paramount importance, and Crane have supplied bronze and cast iron valves for the whole installation. In a plant of such a size, this adds up to a very large number of valves!

Crane also supplied cast iron flanged pipe fittings and malleable iron banded pipe fittings.

All over the world, in many different industries, Crane valves are in use. If you want advice about valves, come to Crane.

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TYPE WSF.

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–makes boilers give their best

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ROTAVAC oil-firing offers—

UNSURPASSED STEAM OUTPUT per pound of fuel, year in year out, without adjustment.

ONLY ONE MOVING PART—the Fan—and that far from the flame means nothing to repair and little to maintain.

PERFECT COMBUSTION OF ANY LIQUID FUEL including the heaviest, cheapest grades. Rotavac's soft, gaseous flame is kind to brickwork and prolongs fire-box life.

ANY FORM OF CONTROL including manual, semi-automatic High/Low, or fully automatic modulation with gas-electric ignition. Send for details of ROBOT ROTAVAC—complete AUTOMATION in the Boilerhouse.

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NU-WAY HEATING PLANTS LTD., BOX (B159) DROITWICH

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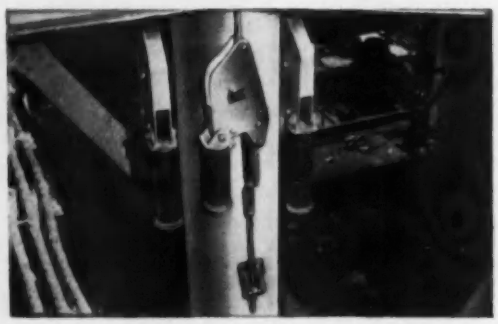
For controlled pipe movement . .

CON-TEN

REG. TRADE MARK

CONSTANT TENSION PIPE SUPPORTS



The Con-Ten system has not only been tested, but *proved* in industries and power stations all over the world. No matter what the load or the pipe movement, or the problems met, there is a Con-Ten to provide the most adequate and *permanent* support available. Loads from 100 lbs. to 14 tons and pipe movements up to 18" can be controlled by constant tension supports in the Con-Ten range. *Contact us now for full information.*

British Patent Nos. 474008 720074 720075 697987 816976
U.S.A. Patent No. 2129320

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CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS.

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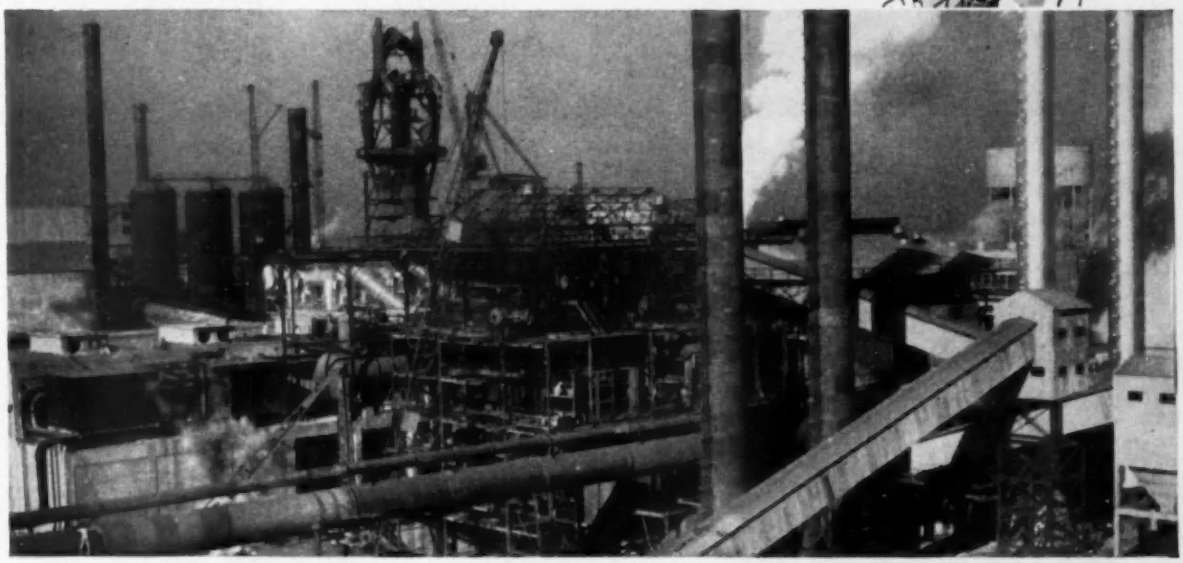
THE POWER BEHIND THE GODDESS

The Steel Goddess was the description given recently to the new Durgapur steelworks. This was apt not only because of its immense importance to Indian steel, but also because Durgapur means 'the place of Durga' and Durga is the ten-armed Goddess of Bengal.

The power behind the annual production of one million ingot tons of steel is one of our many responsibilities at Durgapur. The Goddess's heart, the power plant, will consist of four Simon-Carves water tube boilers producing steam for vital steelworks services; the associated fuel and ash handling plants, cooling system and steam distribution network will all be Simon-Carves designed and built.



COMPLETE POWER PLANT BY ***Simon-Carves Ltd***

SIMON ENGINEERING GROUP

STOCKPORT, ENGLAND

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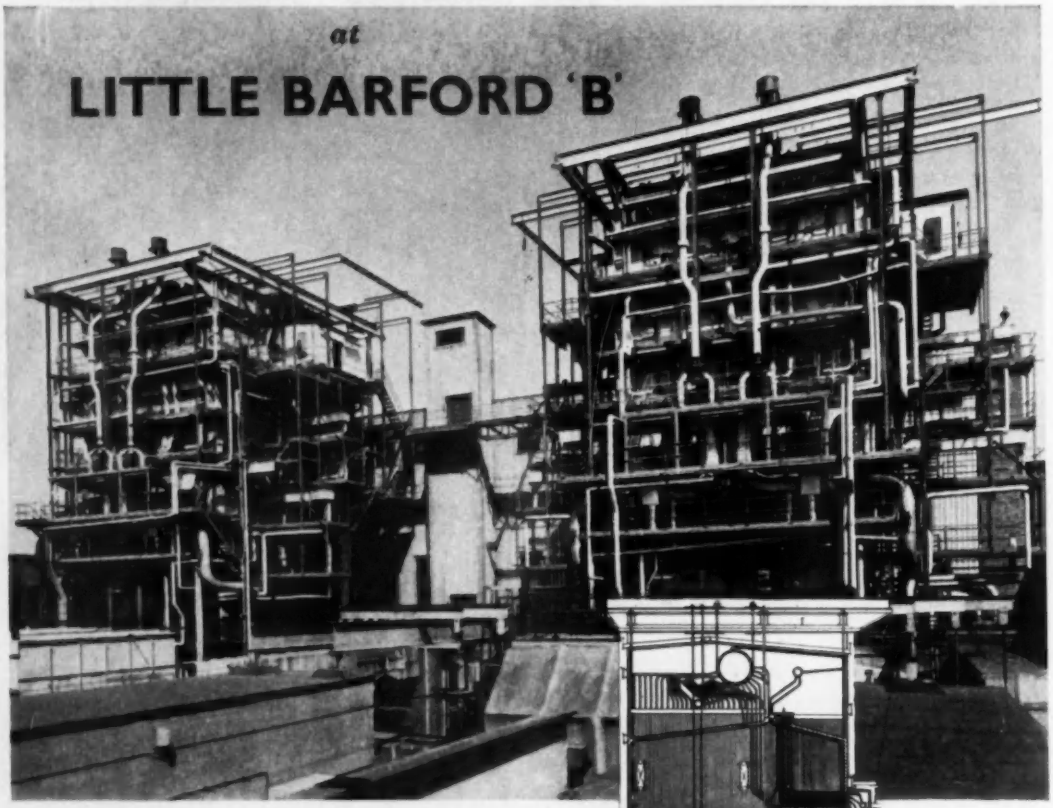
At Durgapur we are also building the coke ovens and coke handling plant, the by-product plant, the coal washery, blending and handling plant and the inter-connecting services for gas, tar and steam.

SC235

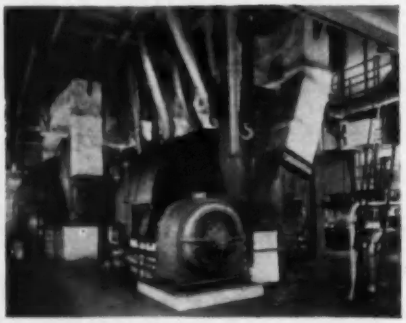
FOSTER WHEELER

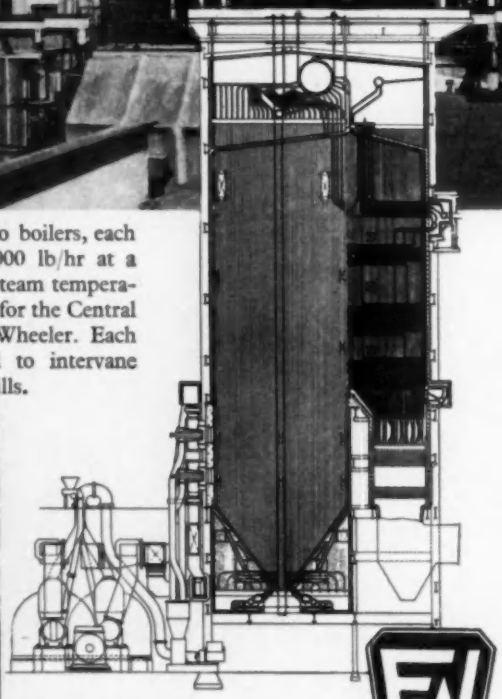
at

LITTLE BARFORD 'B'



This outdoor installation consisting of two boilers, each having a maximum evaporation of 550,000 lb/hr at a pressure of 950 lbs per sq. in. with a final steam temperature of 925° F have been designed and built for the Central Electricity Generating Board by Foster Wheeler. Each boiler is fired with pulverised fuel fed to intervane burners from Foster Wheeler type Ball Mills.





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FOSTER WHEELER LIMITED

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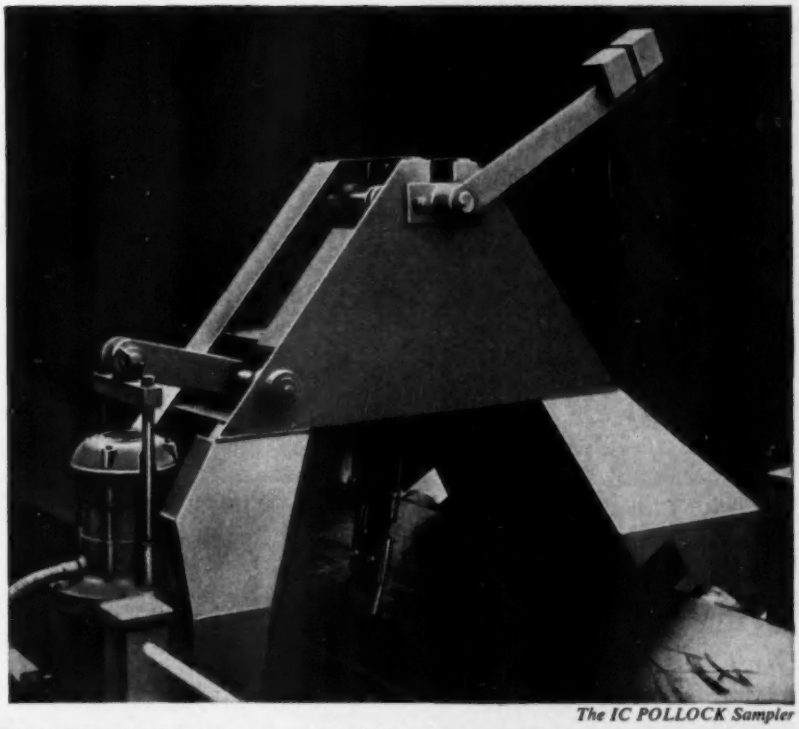
Coal sampling stage by stage

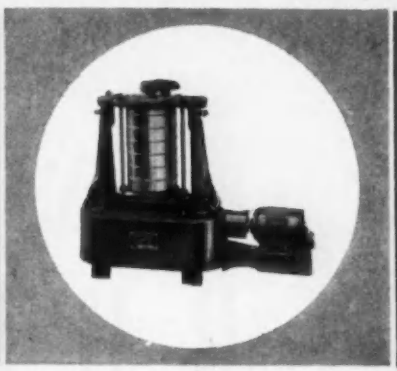
WITH IC LABORATORY EQUIPMENT

The need for accurate sampling of coal and many other bulk materials on belt conveyor installations is met by the IC Pollock Sampler. Simple, robust, and easy to maintain, its reliable performance has been proved by prolonged power station service, and it fully conforms to B.S. limits of accuracy. The Sampler can be readily applied to new or existing belt conveyor installations with minimum alteration to lay-out of plant. It is part of an extensive range of IC Laboratory Equipment for sampling, sizing and grinding through every stage of materials testing.



The IC POLLOCK Sampler

The TYLER Sample Reducer
reduces a large sample to a representative sixteenth part in only one operation. A 1-lb. sample for sieve tests can be obtained from 256 lb. of material with only two reductions.



The RO-TAP Sieve Shaker
provides a uniform mechanical shaking method from test to test. It handles up to thirteen 8-in. diameter sieves in a single operation.

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carries out experimental grinding of non-abrasive dry materials in batches of a few ounces to several pounds at a time. Five interchangeable screens provided for varying degrees of fineness.

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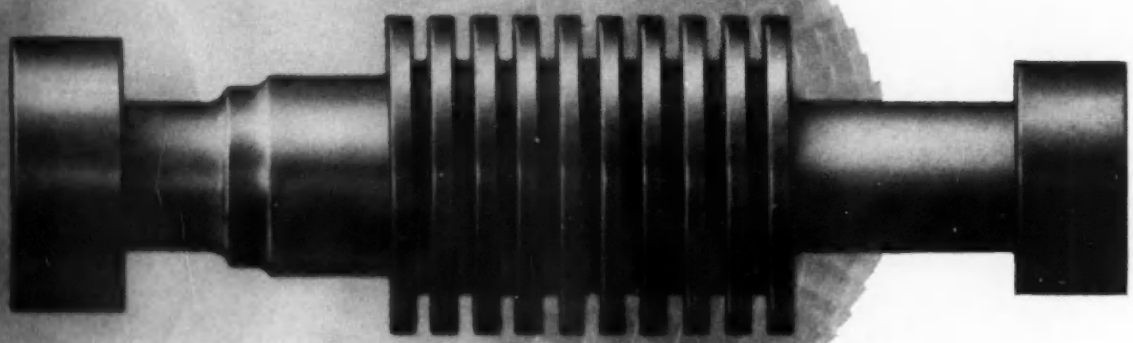

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In the discussions that precede conversion to oil, people are apt to 'stick their necks out' in praising its advantages. To make sure you *do* get all the advantages of oil-firing, bring in Hamworthy for a consultation at an early stage.

Apart from manufacturing a superb burner, Hamworthy offer the full support and co-operation of their technical department from the discussion stage to installation—and after that there is the Hamworthy Service Organisation, offering regular inspection and always available when needed.

Hamworthy burners are ideal for all types of industrial boilers. Contact Hamworthy.

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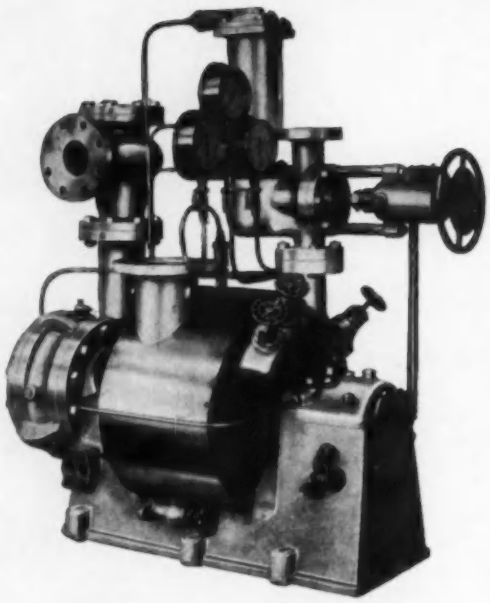

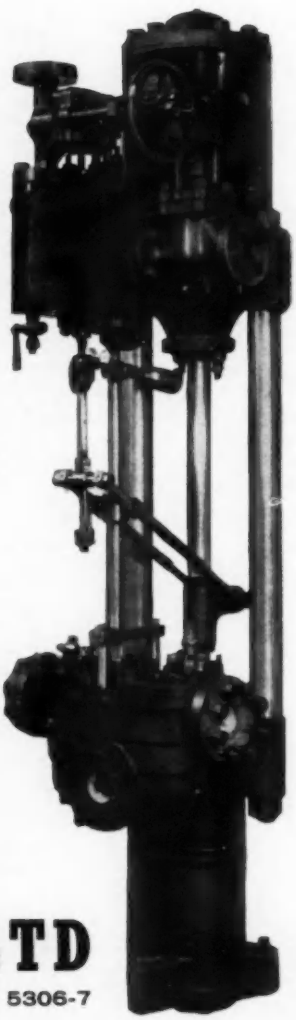

The Hall range of Boiler Feed Pumps includes Direct Acting Reciprocating Pumps of extremely robust construction in capacities from 100 to 10,000 gallons per hour. Also ranges of Turbo Feed Pumps for 4,000 to 37,000 gallons per hour capacities.

These pumps are the products of over 50 years' experience in specialising in Boiler Feed Pump manufacture, concentrating on reliability, efficiency and accessibility.

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Compact, fast, efficient, easy to operate. Air-powered tube rolling up to twelve ¼" to 1½" OD tubes per minute. Precision pneumatic control stops expansion automatically within .001" of predetermined setting.

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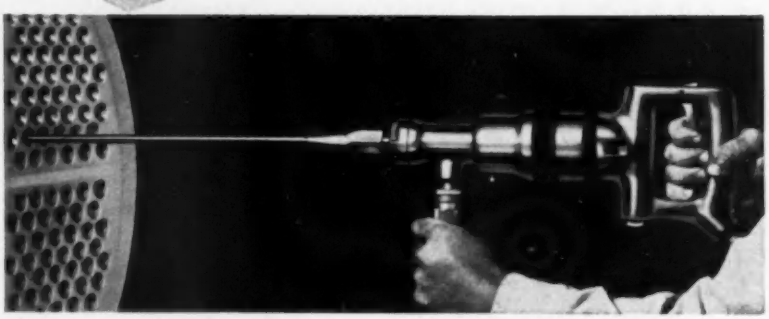

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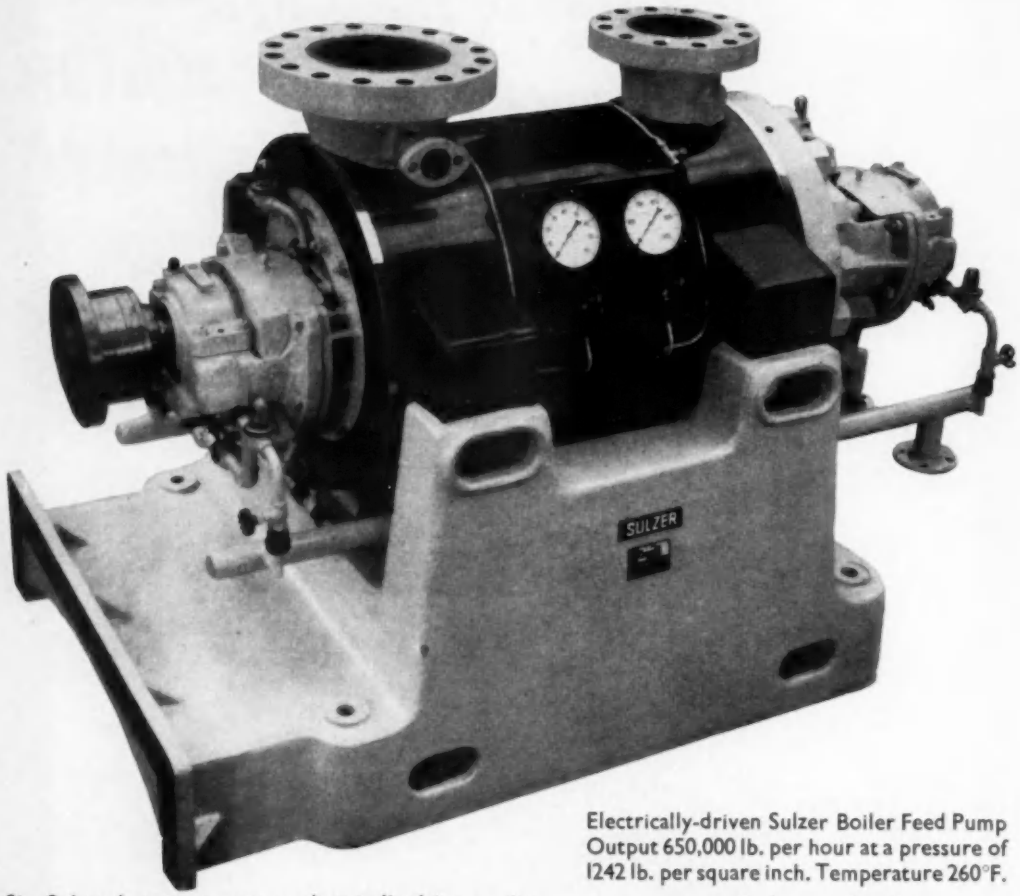
SULZER
BOILER - FEED PUMPS



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one of nine units for MARCHWOOD POWER STATION *of the* **CENTRAL ELECTRICITY GENERATING BOARD**

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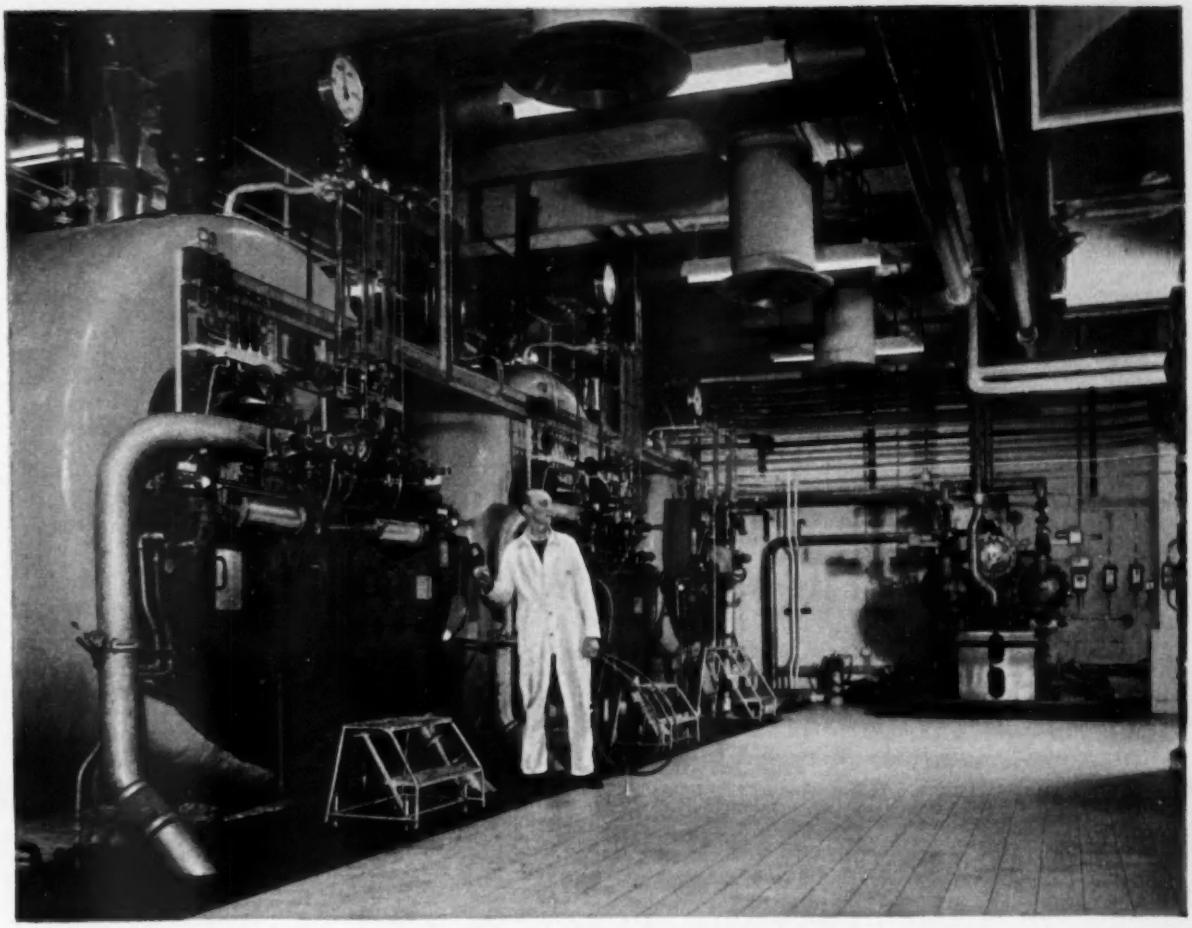

Photograph by courtesy of Aspro-Nicholas Ltd.

Three JOHN THOMPSON
Super Economic Boilers at
Aspro-Nicholas Ltd., Slough.

ESSENTIAL RELIABILITY *for constant process temperatures*

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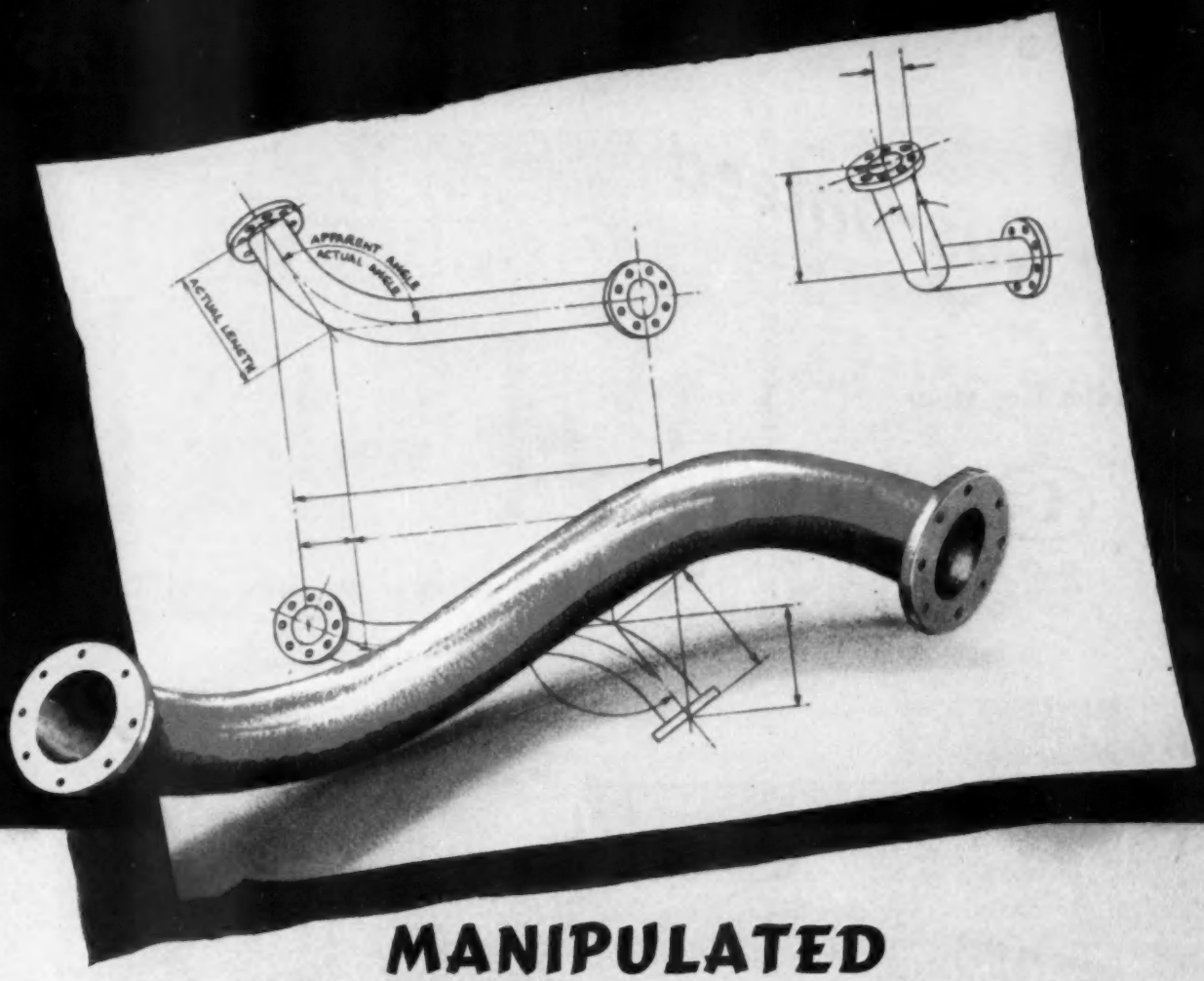

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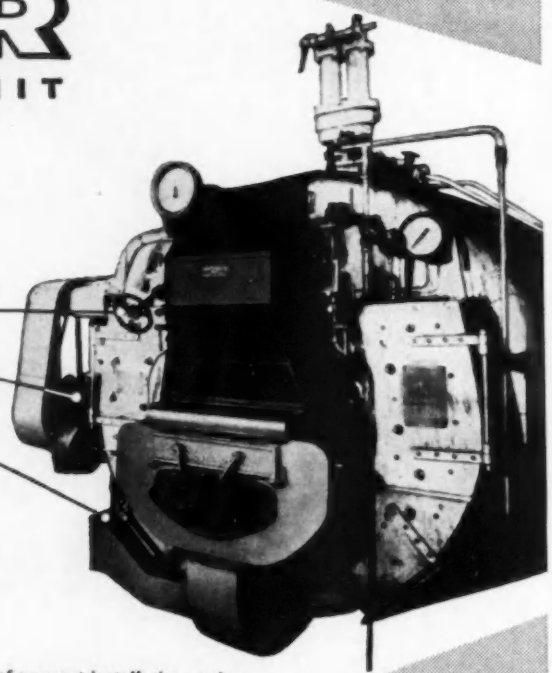

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Part of a recent installation at the St. Lawrence Hospital, Chepstow.

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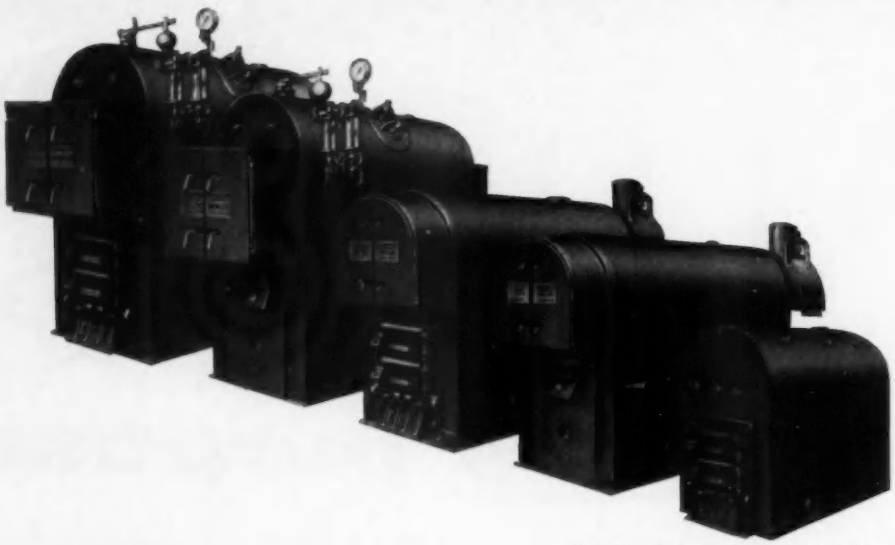

Boilers by Hartley & Sugden Ltd., Halifax

A section of copper piping showing heavy scale deposit

The same section after treatment with Starit

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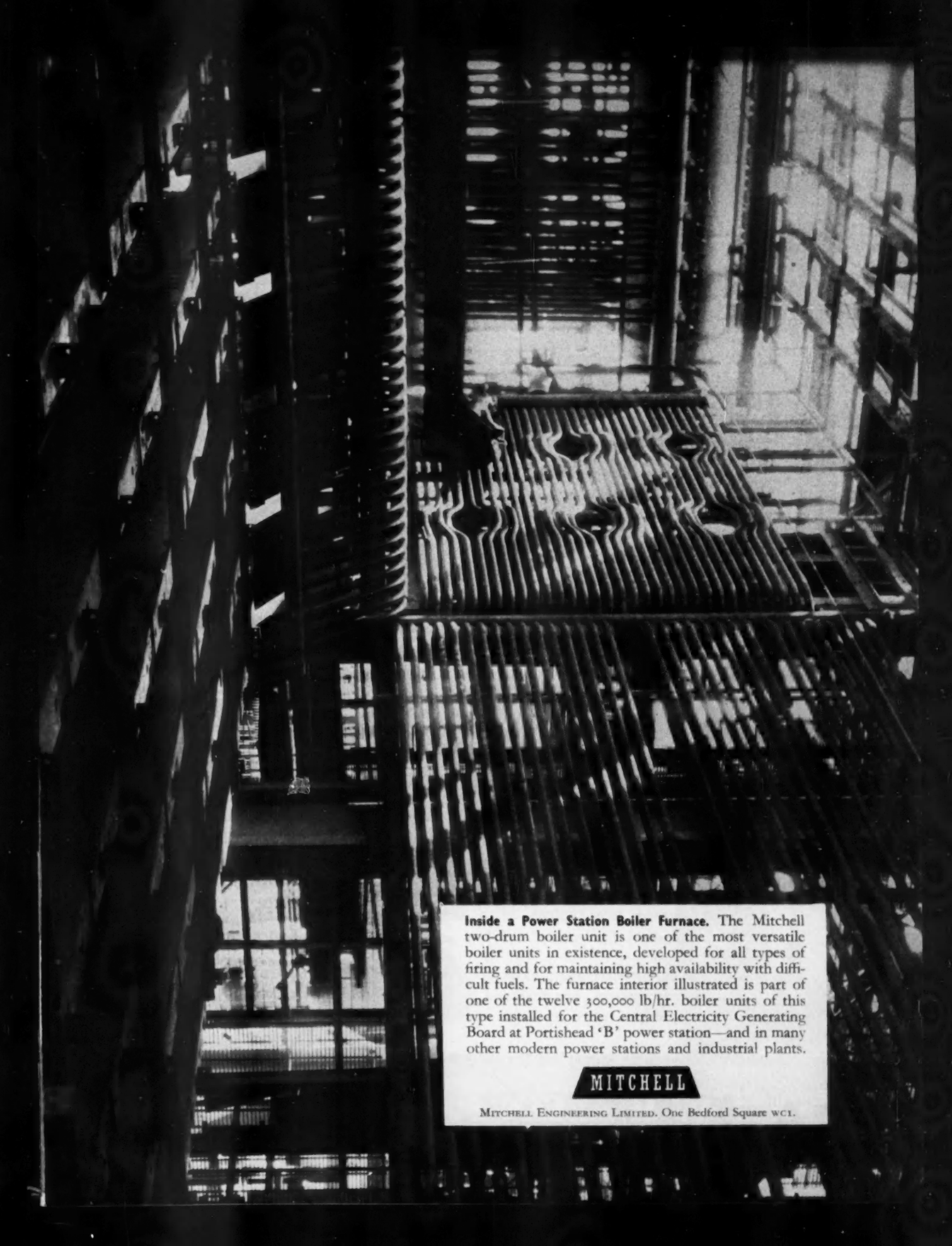

Inside a Power Station Boiler Furnace. The Mitchell two-drum boiler unit is one of the most versatile boiler units in existence, developed for all types of firing and for maintaining high availability with difficult fuels. The furnace interior illustrated is part of one of the twelve 300,000 lb/hr. boiler units of this type installed for the Central Electricity Generating Board at Portishead 'B' power station—and in many other modern power stations and industrial plants.

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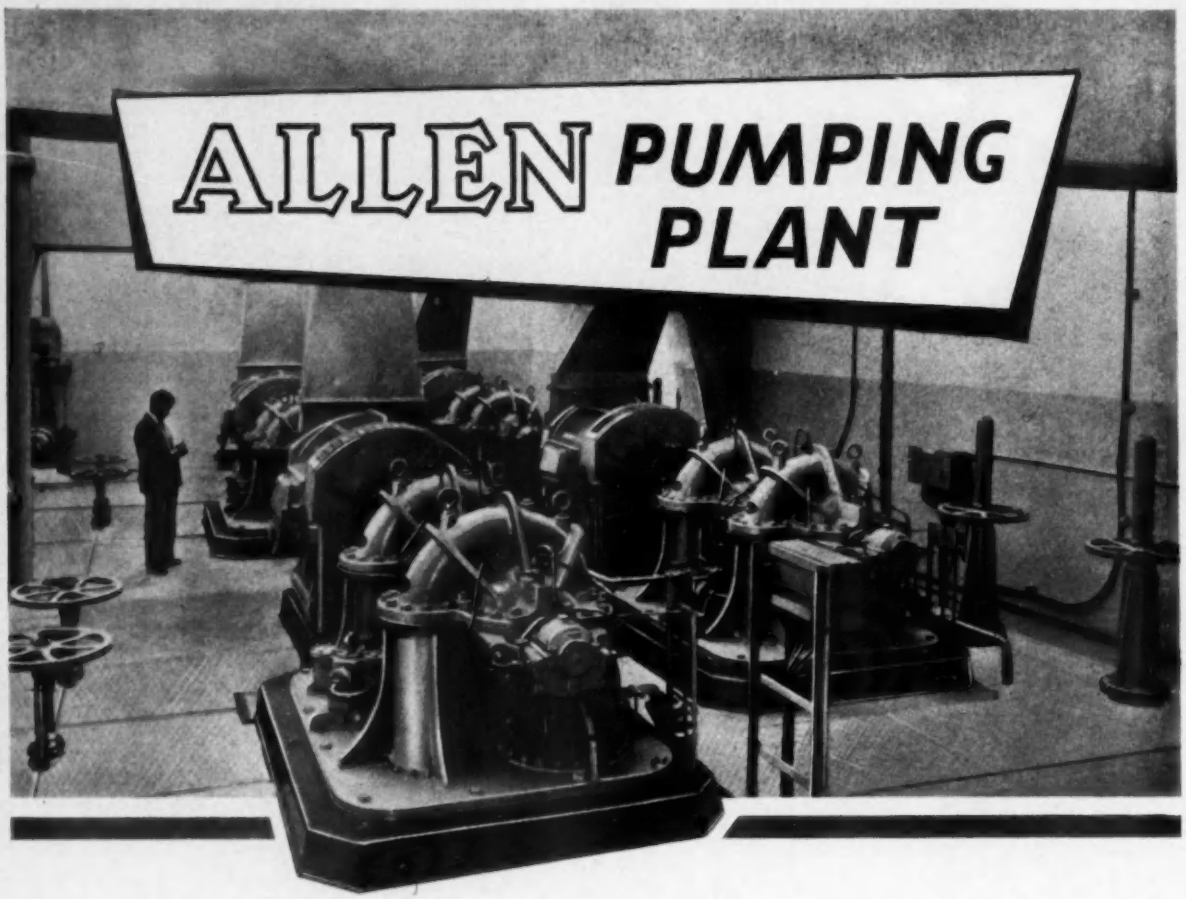

for Power Station Service

The plant illustrated is in service for the Electricity Supply Commission's Highveld Power Station, Orange Free State, South Africa.

It comprises four Allen horizontal double-suction, two-stage pumps with 20/16-in. branches, driven by 1245-h.p. M-V motors. Each pump is designed for a duty of 360,000 gallons per hour against a total head of 490 feet, running at a speed of 1485 r.p.m.

These pumps are typical of a large number of ALLEN units installed for power station and waterworks service.

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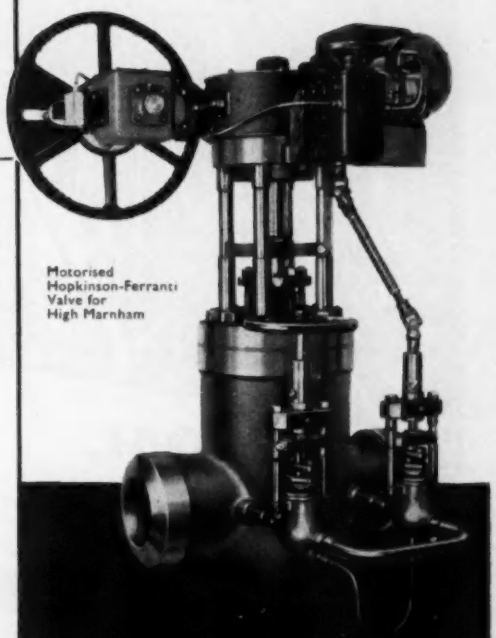
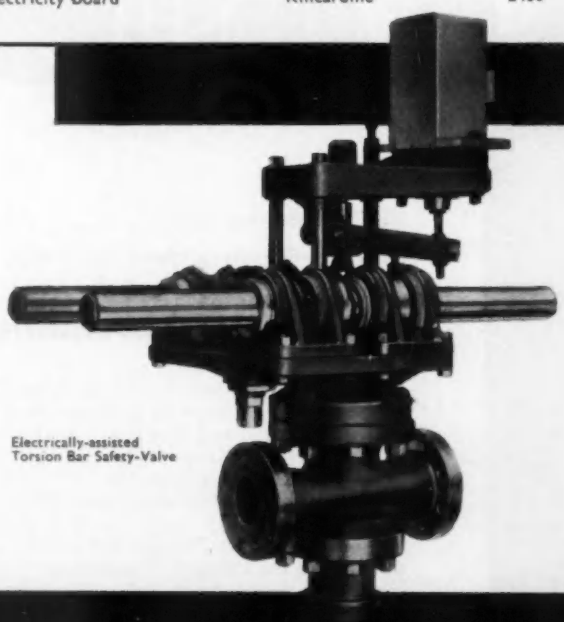
Name of user	Station	lb/sq. in.
Central Electricity Generating Board	High Marnham	2450
Centrale Thermique Minière de l'Est de Charleroi, Belgium	Farciennes	2130
Electricité de France	Emile Huchet	2130
S.A. Charbonnages de Monceau-Fontaine, Belgium	Monceau-sur-Sambre	2160
Elec. Escaut, Belgium	Langerbrugge	2160
Steel Co. of Wales Ltd.	Margam	3150
South Zeeland Power Company, Denmark	Masnedø	2087
Central Electricity Generating Board	Thorpe Marsh	2450
Soc. Meridional di Elettricita	Naples	2558
Electricity Commission of New South Wales	Vales Point	2450
Central Electricity Generating Board	Blyth 'B'	2450
South of Scotland Electricity Board	Kincardine	2450



Motorised Hopkinson-Ferranti Valve for High Marnham



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Motorised Hopkinson-Ferranti Valve for Langerbrugge

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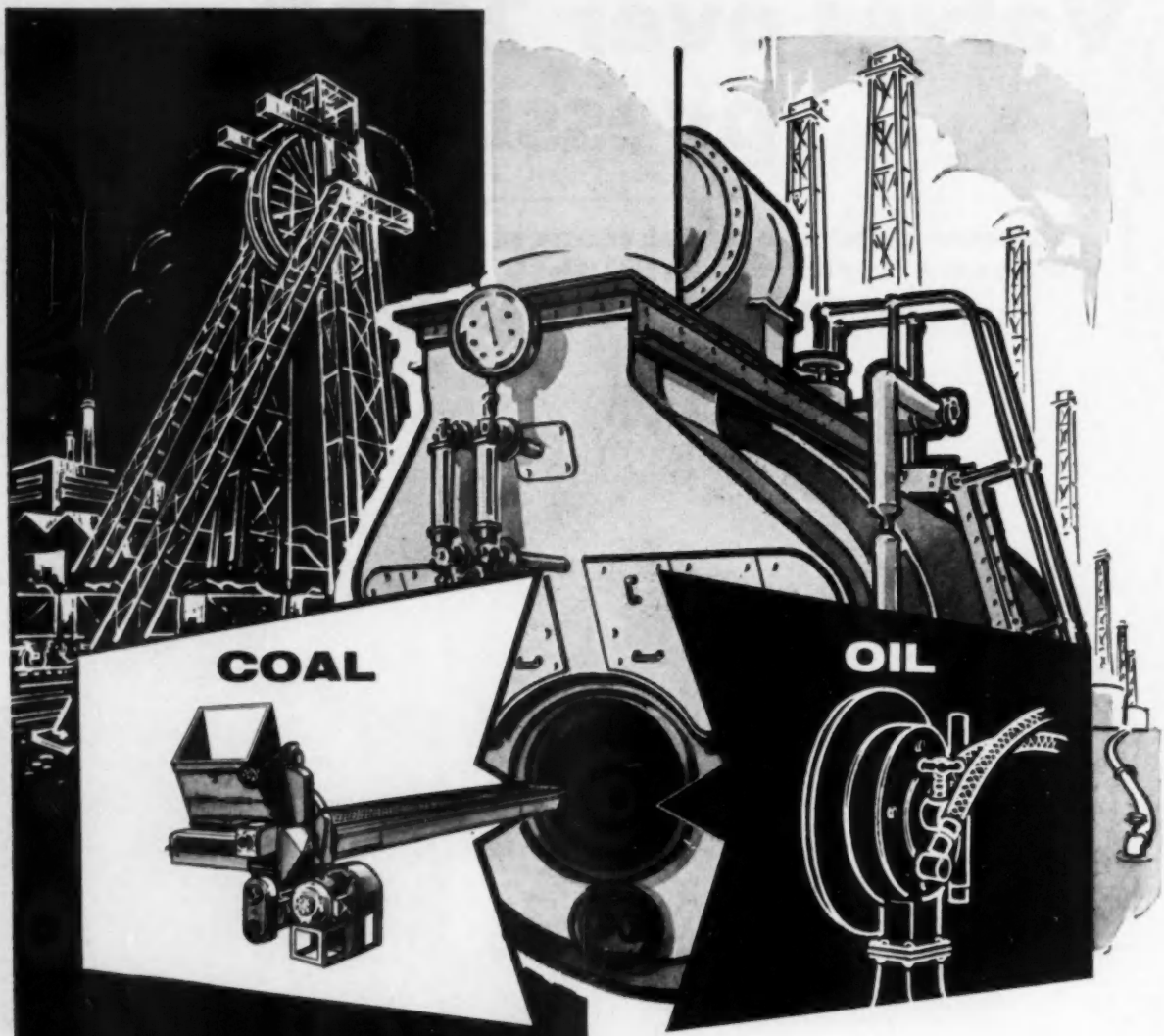

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Engineering and BOILER HOUSE REVIEW

THE OLDEST ESTABLISHED STEAM ENGINEERING PUBLICATION

JULY 1960

VOLUME 75. No. 7

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The Editor will be glad to receive and consider original contributions, correspondence, etc., of a suitable nature for publication. Stamped and addressed envelopes should be enclosed for the return of any matter considered unsuitable

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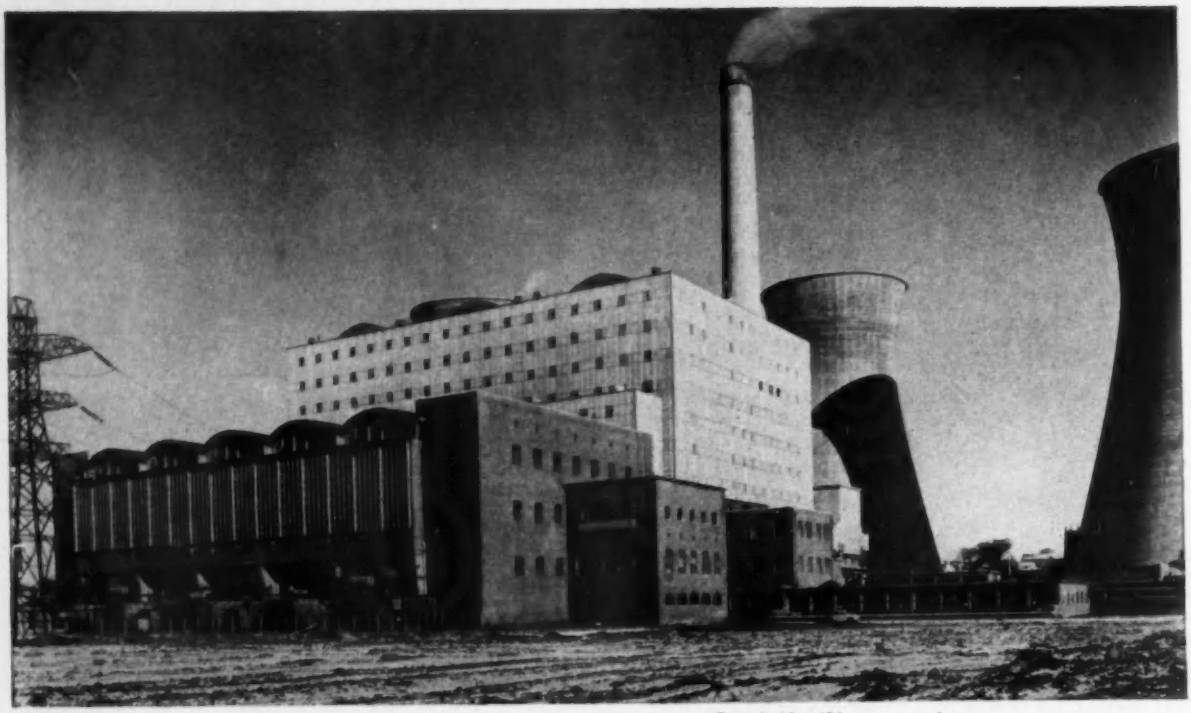
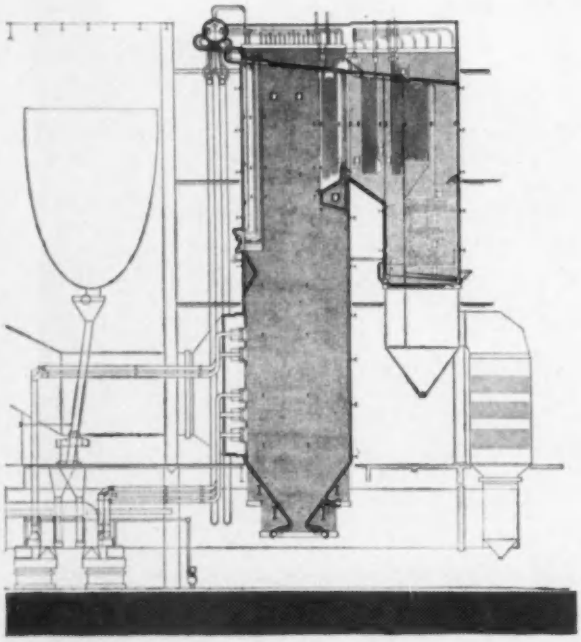


Ferrybridge 'B' power station:
Yorkshire Division, Central Electricity Generating Board.

BABCOCK at *Ferrybridge 'B'*

STEAM-RAISING PLANT



THREE 760,000 lb./hr., P.F.-FIRED, RADIANT-TYPE, 'REHEAT' BOILERS, steaming 100 MW GENERATORS

The Ferrybridge 'B' power station is one of the first to be commissioned of the Central Electricity Generating Board's modern "reheat" installations; with its three Radiant-type reheat boilers, all supplied by the Babcock organization and each steaming a 100 MW generator as a single boiler/turbine unit.

The boilers, each with a capacity of 760,000 lb./hr. M.C.R., at 1,600 lb./sq. in. and 985°F final temperature, with reheat to 955°F, are pulverized fuel-fired by 20 horizontal circular-type burners supplied from five Babcock type 'E' pulverizing mills, per boiler. Other Babcock equipment includes the automatic lighting-up and low-load-carrying oil burners, the automatic, sequence-controlled system of " Unidirectional-drive" and rack-type soot blowers; and Bailey boiler controls.

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Engineering and
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JULY 1960
VOLUME 75 No. 7

REVISED NUCLEAR POWER PROGRAMME

UNDER the revised programme for nuclear power announced in a White Paper published on June 20th, it is pointed out that if the amended 1957 target of 5,000-MW to 6,000-MW of nuclear power by the end of 1966 were to be retained, the electricity authorities would have to place exceptionally large orders for nuclear capacity during the next two years for commissioning in 1965 and 1966. It has, therefore, been decided that the target of about 5,000-MW capacity should be advanced to 1968, which will mean continuing to place orders for nuclear stations at the rate of roughly one every year. The present position is that the five nuclear stations now being built will provide 1,875-MW when all on full load in 1963/64, while another 1,050-MW will be contributed by Dungeness and Sizewell by 1965/66. The order for Dungeness is expected to be placed during the next few weeks and that for Sizewell by the end of the year. Thereafter, there will be one order placed per 12 months. Had it been decided to reach the 1957 target by the end of 1966, three more 550-MW stations would have been necessary.

The decision to make this substantial reduction in the size of the nuclear power programme is a serious blow to the fortune of the manufacturers who have invested heavily in this comparatively new industry, but furthermore, the slow-down seems likely to have its most immediate effect on the United Kingdom Atomic Energy Authority itself, which will have to carry stocks of fuel for a longer time than had been foreseen, and will incur a loss estimated at several million pounds. So far as the manufacturing consortia are concerned, the situation calls for them to preserve their confidence in the future of nuclear power and to maintain their efforts in the interests of this country's home power programme and potential export business.

Since the provisional nuclear power programme of 1958 was presented to Parliament, thermal power stations have advanced rapidly in the efficiency of generation with the commissioning of generating sets working at extra high steam pressures and temperatures, while the capital cost of stations has been reduced by installing fewer sets of greater individual ratings.

Special design features concerning generating sets, such as direct-cooling of rotors, and water-cooled stators, have contributed to economy by increasing the output obtainable from machines of a given size. By the time the accelerated nuclear programme was first announced in March, 1957, the commissioning of 100-MW sets had already commenced, and the first 120-MW machine was placed in service early in the following year. Average thermal efficiencies were continuing to improve, and had risen from 24.35 per cent. in 1956, to 25.51 per cent. at the time of the announcement of the accelerated programme for nuclear stations. The improvement has since continued to an average thermal efficiency of 26.36 per cent. in 1959—with the average figure for the 20 most efficient stations reaching 30.67 per cent.—the best return being shown by Blyth "A" with 33.88 per cent.

These trends were likely to make some difference to the relative importance of nuclear and thermal power generation in a national programme. Furthermore, the decision taken early in 1957 to increase nuclear generating capacity as compared with the 1955 proposals, was influenced by the prevailing fuel situation, and the curtailing of the target in September of the same year was made necessary by restrictions on capital investment. Since then, the part that thermal power generation can play has become more important both in view of the technical advances referred to above, and of a changed fuel situation in which coal has become plentiful and fuel oil supplies have also improved, while benefits are already being gained from the policy of the C.E.G.B., of siting new power stations, adjacent to, or in close proximity to, sources of low-priced coal.

Under such conditions, the need for an immediate and sharp acceleration in the rate of ordering nuclear generating capacity is unnecessary. It has been officially stated that, at the present time, conventional power costs are about 25 per cent. less than nuclear costs in this country, and the break-even point between the two will not be reached as early as had been estimated. It is now suggested that nuclear power generation for base-load requirements may possibly become cheaper than thermal generation by about 1970. Continued experience by the research and design staffs of the nuclear power consortia is necessary if this state of affairs is to be reached in a reasonable time. At a Press conference on June 20th, The Rt. Hon. Richard Wood, M.P., Minister of Power, and Sir Christopher Hinton, chairman of the Central Electricity Generating Board, both emphasised that the effect of the slowing down of the nuclear programme on the consortia was one of the most important factors considered. Sir Christopher added that "the Generating Board never considered it part of their business to tell industry how to organise itself. We are now letting industry know what volume of orders we shall be placing so that they can organise themselves in the way they think right to meet that volume of trade."

Points and Pointers

INVESTIGATION OF SITES FOR COAL-FIRED POWER STATIONS The Central Electricity Generating Board announce that as part of the continuing process of seeking possible sites for new power stations, they will be investigating six areas in the West Riding of Yorkshire to explore their suitability for large coal-fired stations. Sites adjoining the existing power stations ("A" and "B") at Ferrybridge, and the new station under construction at Thorpe Marsh, near Doncaster, will be examined along with four new areas at Knottingley, Kellingley, Eggborough and Gowdall, near the course of the River Aire between Knottingley and Goole. The investigations will include numerous trial borings to verify the subsoil conditions, and are expected to take several months to complete. The amount of electricity consumption is rising faster than ever before, and it is necessary to be planning ahead for the additional coal-fired power stations likely to be required in the later 1960's and beyond. The Yorkshire coalfield at present produces large quantities of the small coals that can be used for electricity generation, its contribution being exceeded only by that of the adjoining East Midlands coalfield, and it possesses large reserves of economically workable coals of various types. Increasing quantities, suitable for electricity generation, are expected to become available in the future, and if sites with the right combination of facilities for large power stations can be found near the coalfield, it will be possible to use this coal efficiently and economically for electricity generation with advantage both to electricity consumers and the coal industry. Coal-fired power stations already working or planned near the Yorkshire coalfield include Wakefield "B" (240-MW) and Elland (180-MW) on the River Calder, Ferrybridge "B" (300-MW) and Skelton Grange "B" near Leeds (480-MW) on the River Aire, and Thorpe Marsh, near Doncaster (1,100-MW) on the River Don. Any power station proposals arising from these investigations will be published and will, of course, be the subject of applications to the Local Planning Authority and to the Minister of Power for statutory consents.

"SURVEY OF THE EUROPEAN COMMON MARKET FOR ELECTRICAL PRODUCTS" A 60-page "Survey of the European Common Market for Electrical Products."—believed to be the first comprehensive survey of its kind to be undertaken by a trade association—has been published by the British Electrical & Allied Manufacturers' Association, to assist members in their export trade by assessing the future market for electrical products of all kinds in the "Six" countries. The survey was prepared by the economist, Mr. A. S. Windett. The importance of this market for electrical products is shown by the estimates of future trends in demand which are given in the survey. The figures show that the total installation of purchase rate of electrical products by the "Six" in 1958 was of the order of £2,300 millions, and it is estimated that by 1963 the installation rate will have risen to £3,300 millions, or by about 44 per cent. Over the five years, 1959-63, the Common Market countries will have absorbed electrical products amounting to a total of about £14,000 million, equivalent to 10 years of United Kingdom output at present production levels. It is estimated that over the period 1959-60 the total value of domestic electrical equipment to be bought or installed in the "Six" will be about £1,900 millions. All these figures are broken down into product categories and individual territories. The vital importance of the market to the electrical industry gives point to the successful efforts made by the BEAMA to secure greater co-operation between the industry in the "Six" and the "Seven." The Survey, which includes 62 tables of statistics, makes an assessment of the size of the future market for electrical products in the "Six" countries, collectively and individually; it discusses the social, geographic and economic factors which have had to be taken into account, and gives much detailed "background" information relating to each of the countries and principal users of electrical plant and equipment.

OBTAINING GAS FROM LOW-GRADE COAL The economics of a new complete gasification process for obtaining gas from low-grade coal are to be investigated at a pilot plant which is to be built at the North Thames Gas Board's works at Bromley-by-Bow, London. The pilot plant will be operated as an experimental unit by the London Research Station of the Gas Council, and its capital cost will be approximately £225,000. It is expected to produce about 2 million cu. ft. of blue water gas per day. The contract for its construction has been placed with Simon-Carves Limited, who are working in conjunction with Dr. C. Otto and Company of Bochum, West Germany. Work has already started, and will be completed in about a year. The decision to build this plant has arisen from the need for a process which will gasify the cheapest grades of coal completely, producing blue water gas on a large scale at the lowest possible cost. The intention is that this cheap blue water gas would be mixed with a cheap rich gas—such as imported methane, gas obtained from oil, gasification, or tail gases from refineries—to provide towns' gas at the statutory calorific value. This has become necessary because it is now more expensive to manufacture "lean," or low-calorific, gas in existing conventional plants than it is to produce rich, or high-calorific gas. It is essential, however, to have supplies of "lean" gas in order to reduce the calorific value of rich gases to a standard level. Interest in complete gasification of coal has also arisen because of the shortage of the conventional coking coals which the gas industry has always used in the past; as a result, there is the prospect of a coming shortage of the good quality coke which is used to manufacture blue water gas in conventional plant. Because of this prospect, work was started in the Gas Council's London Research Station some 10

years ago, to find new methods of producing blue water gas. A comprehensive survey of all known methods, and methods which were only in the early development stage, was carried out. The result of this survey was that attention was focused on a process known as the slag-bath generator which has been developed in Germany from an invention by Herr Rummel of the Union Kraftstoff A.G. This process involves forcing powdered-coal, together with air or oxygen and steam, into a bed of molten slag, which produces blue water gas continuously. This process in a somewhat different form has been operated on a large scale in Germany, using brown coal as a fuel. In this country, where there are no considerable quantities of brown coal, modifications have been made, and the pilot plant will utilise powdered low-rank black coal as a fuel, and use air instead of oxygen in the processing. Because of this use of air instead of oxygen, the slag-bath generator which it is proposed using in the pilot plant at Bromley will consist of a twin-shaft system and a divided slag-bath in one part of which coal is burned in air with combustion products escaping up one of the shafts. In the other part, coal will react with steam in the presence of molten slag, heated by the combustion in the first half of the bath, to produce blue water gas. The molten slag will be kept circulating under a dividing curtain so that heat generated on the combustion side is carried into the gas-making side to provide the heat required in the process. This is a complete gasification process, there being no by-products except slag.

THE WORK OF N.I.F.E.S. In a speech which he made at the opening of the recent Fuel Efficiency and Power for Industry Exhibition, Sir Dennis Proctor, K.C.B., permanent secretary of the Ministry of Power, said that the statistical branch of his department has made an analysis of the changes in coal consumption in industry over the three years 1955 to 1958, during which the level of industrial activity, as a whole, remained very much the same. Over these three years, the annual consumption of coal by industry fell by about 8½ million tons, and of this reduction in the annual rate, it is reckoned that about 3-million tons was due to the growth in the use of oil. The remainder—about 5½-million tons, or nearly two-thirds—was due to other causes of which the biggest must have been the steady improvement in fuel efficiency. The results in those cases which have been the subject of special heat and power surveys by the National Industrial Fuel Efficiency Service, are even more striking. In these cases, the average improvement of fuel efficiency after a survey has been of the order of 20 per cent. Fuel efficiency is, said Sir Dennis, a vital ingredient of all productive efficiency—perhaps the most important element of all—and he was sure that no one is likely to fall into the error of thinking that because the days of fuel shortages are now mercifully over, there is no longer any need for efficiency in the consumption of fuel. Fuel efficiency is as important as it ever was—indeed, more so, because competition is that much keener now that the world has moved into the phase of a buyer's market. It is essential to our livelihood as a nation that our industrialists should be able to quote competitive prices. Competitive prices can only be achieved by competitive costs, and competitive costs mean wringing the last ounce of efficiency out of every part of the process of production. He also said that a special word was due, to the National Industrial Fuel Efficiency Service, under its chairman, Sir Leslie Hollinghurst. N.I.F.E.S. (to give it its popular name) has been in existence for six years, and its activities are many-sided. One of its most important sides is that concerned with the human element, by which such things as standards of maintenance, levels of management and methods of operation; things which are vital to the attainment of a high standard of efficiency, Sir Dennis said that was why he specially welcomed the opportunity at this ceremony of presenting the prizes given by N.I.F.E.S. to some of the selected prize winners who have obtained the Boiler Operators Certificate at the City & Guilds examinations last year. The certificate itself was introduced in 1953, and since then over 7,600 candidates have successfully obtained the certificates, and of these, just over a third have been prepared for the examination in the courses organised by N.I.F.E.S. themselves. These results reflect great credit on those who have organised the training courses, whether in the separate industries or in N.I.F.E.S., on the engineers who have given the courses, on the employers who have encouraged their men to take the courses, and made it possible for them to do so, and, last but not least, on the candidates themselves who have had the enterprise to take the examination and the grit to get through it successfully.

BIRTHDAY HONOURS The official birthday of Her Majesty the Queen was celebrated on Saturday, June 11th. The Birthday Honours List, published on that day, appears to contain fewer names than usual of engineers, and of those closely concerned with the engineering and allied industries. Among the honours to be conferred, the following are included: *Knighthoods*—Mr. W. H. McFadzean, president, Federation of British Industries; Mr. B. F. J. Schonland, director, Research Group, United Kingdom Atomic Energy Authority; Mr. G. B. B. McIvor Sutherland, director, National Physical Laboratory; Brigadier M. H. Cox, formerly Additional Director-General of Ordnance Factories in India. *K.C.B.*—Mr. A. J. Sims, director-general, ships, Admiralty. *C.B.*—Mr. F. M. Lea, director, Building Research Station, D.S.I.R.; Mr. J. S. McPetrie, director-general of electronics research and development, Ministry of Aviation. *K.B.E.*—Mr. Robert Cockburn, chief scientist, Ministry of Aviation; Mr. C. Robertson King, chairman, Electricity Council. *C.B.E.*—Mr. T. E. Allibone, director, Research Laboratory, Associated Electrical Industries Limited, Aldermaston; Mr. E. J. Hunter, chairman, Swan, Hunter and Wigham Richardson Limited; Mr. H. S. Keep, assistant chief engineer, Ministry of Transport; Mr. J. C. McKell, joint managing director, Ralston and McKell Limited; Mr. W. G. Mitchell, director, Mitchell Bros. Sons and Co. Ltd.; Mr. R. A. Smith, chief scientific officer, Royal Radar Establishment, Ministry of Aviation; Mr. J. C. C. Stewart, deputy managing director, productive group, United Kingdom Atomic Energy Authority; Mr. P. H. L. Thomas, lately commissioner (engineering adviser), Civil Service Commission, and Mr. R. L. Wyllie, chairman, West Cumberland Industrial Development Co. Ltd.; Mr. F. J. Erroll, M.P., M.A., M.I.E.E., Minister of State, Board of Trade, becomes a Privy Councillor.

Advanced Gas-Cooled Reactor at Windscale

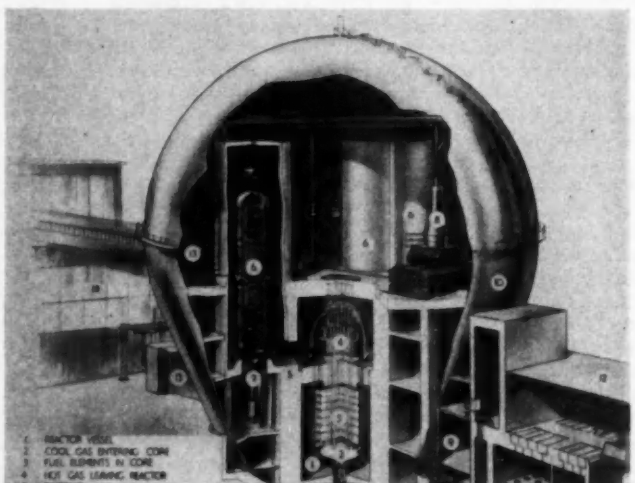
The Advanced Gas-Cooled Reactor (A.G.R.) now being built by the U.K. Atomic Energy Authority at Windscale to serve as a prototype for future power station reactors, has a thermal rating of 100-MW (27.3-MW net electrical). Part of the uranium dioxide fuel will be clad in beryllium, and part in stainless steel. It offers the prospects of some considerable reduction in the cost of nuclear power generation

WHAT might be termed new and old techniques in atomic energy confront each other at the Windscale (Cumberland) works of the United Kingdom Atomic Energy Authority. Almost within the shadow of the 380 ft. high ventilating shafts and sealed-up buildings of the former Windscale reactors, the prototype of the advanced gas-cooled type of reactor—which offers the next prospect of substantial improvement in the efficiency of nuclear power stations—is well on the way to completion, together with the research plant and equipment, and specialised workshops associated with it. By courtesy, of the U.K.A.E.A. we recently visited the site, and thus were able to see the progress being made.

The reactor, whose main functions will be to test fuel elements, and provide experience of the operating conditions and physics of this advanced system, is more than three-quarters complete, and should be ready for commissioning by April next year. It will be the first British reactor—built as a prototype—to use enriched fuel. Its cost will be approximately £9 million or, including all new research and other equipment associated with it, nearer to £12 million. The reactors of the nuclear power stations at present being built for the Electricity Authorities are developments of the Calder Hall type of unit, and while they show considerable advances in size and in their engineering development, their fuel elements differ only in detail. The fuel for these stations is in the form of uranium bar of approximately 1-in. dia., sealed in a magnesium alloy can; the differences are limited to variations in finning the can and in methods of supporting the fuel element in the reactor. This type of fuel element imposes two limitations on reactor operation:—the rate at which heat can be produced in the fuel, and the temperature to which the carbon-dioxide coolant can be heated. These limitations in turn restrict the power which can be generated in a reactor of a given size, and the efficiency with which this power can be converted to electricity through the steam cycle.

There are two reasons why the rate of heat production (usually called the "fuel rating") is limited to a mean of about 2.5-MW per ton of fuel, and the can surface temperature, which controls the carbon-dioxide temperature, limited to a nominal figure of 450 deg. C. If either of these figures were to be appreciably increased, the can itself would lose tensile strength as the melting point of the magnox alloy was approached, and at the same time, the temperature of the uranium at the centre of the bar would reach 660 deg. C., at which a change takes place in the crystal structure of uranium. This change, called the alpha-beta phase change, results in a sudden expansion of the uranium which would impose severe stresses on the can. These stresses, coinciding with a weakening of the magnox, would result in the rupture of many of the cans, allowing the escape of fission products which it is one of the main purposes of the can to prevent. Thus, any large improvement in fuel rating or reactor temperature necessitates a complete change in the fuel element, and this is the principal new feature of the advanced gas-cooled reactor. The effects of phase change in the uranium are avoided by using uranium oxide in place of metallic uranium, while the loss of strength in the can is overcome by replacing magnox by a more refractory material. Two materials are being tried out—the first is beryllium, a comparatively novel metal which absorbs very few neutrons, and the other the widely-known stainless-steel.

These changes, of course, introduce new problems. Uranium oxide is a much poorer conductor of heat than the metal, and so the rods of fuel have to be made much



Cut-away view giving an impression of the advanced gas-cooled reactor and associated equipment now being built at Windscale by the U.K.A.E.A.

thinner. This means a greater proportion of canning material to fuel, and a less efficient system from the nuclear physics aspect; also, the presence of two oxygen atoms to every uranium atom reduces the proportion of fissile atoms in the fuel. For these reasons, some enrichment of the fuel, by artificially increasing the percentage of uranium 235, is necessary, though this is partly offset by using beryllium in place of magnox for the can, since it captures far fewer neutrons.

However, it is expected that with this new fuel, the rating can be increased to more than six times the rating of the Calder Hall reactors, which means that more than six times the power can be produced in a reactor of the same size. In addition, it will be possible to increase the carbon-dioxide temperature by over 200 deg. C., which will raise the efficiency of the steam-cycle by something like one-third.

Because the advanced gas-cooled reactor differs very little in its general principles (other than the fuel element) from the current power reactors, it will be possible to introduce this type into the power programme fairly readily.

Thus, the advanced gas-cooled reactor can be regarded as the successor to the magnox reactor for nuclear power stations likely to come into operation in the late 1960s. Like them, it will be a source of plutonium for the initial fuelling of commercial fast reactors which are expected to be introduced in the mid 1970s.

The size of this advanced gas-cooled reactor (A.G.R.) has been chosen at 100-MW (heat) to obtain statistical information on the behaviour of fuel elements in operation. The reactor incorporates five loop systems for the testing of fuel elements under more varied and advanced conditions than are possible in the reactor, in order to obtain an operational lead on their performance. The reactor is designed for maximum flux range rather than maximum output, and is, therefore, not flattened. Experiments will be carried out on the fuel elements, graphite reactions and stability over a wide range of temperatures and ratings. The refuelling of the reactor at pressure, and on power, and the individual "gagging" of channels to control mass flow will assist in the experimental work.

The advancement of the system

More than one-third of the cost of electricity which will be generated in the present civil nuclear power stations will be contributed by the capital cost of the nuclear components, i.e., the reactor and its associated equipment. There is, therefore, great potential for reducing the cost of electricity by reduction of these capital costs. There are two obvious ways of bringing this about:—

(1) By increase in the rating of the fuel which increases the output per unit volume and hence decreases the size of the reactor core, the reactor pressure-vessel, the biological shielding and the associated buildings. The reduction in the size of the reactor vessel also enables a greater pressure to be used for a given shell thickness—this enhances the heat transfer performance of the fuel elements and the heat-exchanger, and reduces the fraction of the power used to circulate the coolant gas.

(2) By increase in the coolant outlet temperature from the reactor, thereby increasing the thermodynamic efficiency of the steam-cycle and enabling a reactor of smaller heat output to be built for the same electrical output. This increase in temperature is brought about by increasing the fuel element surface temperature and, to a smaller extent, by the enhanced heat-transfer performance arising from the increase in pressure.

The advanced nature of the reactor is clearly seen from the following figures, where the rating and temperatures are compared with Calder Hall and the Magnox civil stations:

	Calder Hall	Magnox Reactors	Windscale A.G.R.
Maximum fuel rating (MW/Te uranium)	3	4-5.5	19.5
Inlet coolant temperature (deg. C.) ...	140	160-200	250-325
Outlet coolant temperature (deg. C.) ...	336	345-400	500-575
Coolant pressure (lb./sq. in. g.) ...	100	125-240	270

The outlet coolant temperature on A.G.R. would permit, with an optimised power reactor, the adoption of a modern turbo-alternator, giving a net station efficiency in excess of 38 per cent. This compares favourably with the 25-30 per cent. attainable with the Magnox stations, and gives an increase of almost one-half in the electrical output of the station for the same reactor heat output.

The fuel element

The high temperatures of operation on A.G.R. are achieved by the adoption of the ceramic uranium dioxide as the fuel, and beryllium or stainless-steel as the canning material. Uranium dioxide has a high melting point of 2,800 deg. C. and an ability to withstand high irradiation doses. It is confidently expected that irradiation substantially in excess of 6,000 MWD/Te will be attainable. Beryllium has a very low neutron absorption cross-section and a high thermal conductivity. It is, however, relatively little known, and has a low ductility. Its melting point is 1,280 deg. C. The design operating surface temperature (Tsm) of the beryllium can, which is limited by its compatibility with CO_2, is 600 deg. C. Stainless-steel has the disadvantages of high neutron absorption cross-section (which demands greater enrichment of the fuel) and low thermal conductivity. Some 20 per cent. of the first charge of A.G.R. will consist of stainless-steel canned fuel elements. Its melting point is 1,280 deg. C. and the Tsm is 650 deg. C. The high rating is obtained by the adoption of a cluster arrangement for the fuel element, to give a large specific surface area. This also ensures that the maximum operating temperature of the uranium dioxide is kept to an acceptable figure, thus preventing any appreciable release from the oxide under irradiation of gaseous fission products which must be retained within the beryllium or stainless-steel can.

In the beryllium design, each cluster contains 36 fuel-element rods, 0.3 in. dia. and 12 in. long, and there are three clusters per fuel-element assembly. The rods are held in position between beryllium support plates, which in turn are located by graphite (inner) sleeves, the whole assembly being contained within an outer graphite sleeve. There are four such assemblies to each channel, and they are held together by a central stainless-steel tie-rod which is suspended from the lower-end of the neutron shield plug. The complete stringer of fuel element assemblies and plugs extending up to the re-

fuelling face is charged and discharged as one single unit. The stainless-steel design is similar, except that there are only 21 fuel-element rods per cluster, and each rod is 0.4 in. dia. by 18 in. long, and there are two clusters per fuel-element assembly. In both designs, the uranium dioxide is manufactured in pellets of length equal to their diameter.

The high rating gives a correspondingly higher temperature transient under fault conditions; this being more than offset, however, by the large temperature margin between the operating temperature and the melting points of the fuel and canning materials. Should higher irradiations than the 6,000 MWD/Te referred to above be attained, there will be a corresponding reduction in the fuel replacement costs.

Special features of the A.G.R.

The A.G.R. design incorporates several novel features, viz.—

(1) *Internal neutron shield*

This is mounted immediately above the graphite core. It consists of layers of graphite and boron steel which respectively thermalise and absorb the fast neutrons emitted from the core.

(2) *Co-planar support of reactor vessel and heat-exchangers*

This eliminates vertical expansion problems and permits the adoption of concentric gas-ducts between the reactor vessel and heat-exchangers.

(3) *Re-entrant principle of gas-flow*

Temperature and pressure effects are divorced as far as possible. The outer pressure-shell operates at inlet gas-temperature to the reactor. The inner-shell is insulated internally; it contains the hot gas at reactor outlet temperature, but takes only the differential pressure across the circulator. The re-entrant principle results in the economiser (the coldest region) being at the upper end of the heat-exchanger, with consequent advantage to the natural-circulation of the coolant in the event of failure of the main circulators.

(4) *Re-entrant core*

A re-entrant principle has been adopted for the flow of coolant gas through the core. A part of the inlet gas to the reactor cools the pressure shell, the remainder flows through passages between the graphite bricks of the core. A small amount of heat is generated in the graphite, which, therefore, operates substantially at a steady temperature only slightly in excess of that at the inlet of the reactor. The temperature is sufficiently high to prevent the build-up of releasable (Wigner) energy. The advantage of the design is that transient effects giving rise to variation in fuel and coolant temperatures will have little effect on the graphite moderator temperature.

(5) *Single channel access*

Each channel in the core has a corresponding branch in the head of the reactor vessel. This allows the complete stringer of fuel element assemblies and shield plugs to be withdrawn as a single unit, thus eliminating the necessity for remote operation of grabs and internal latching devices. It also facilitates instrumentation of the fuel elements; up to seven thermocouples may be installed in each channel.

(6) *Individual flow-control on each channel*

A sleeve valve at the outlet gas manifold level is installed in each channel, thus allowing individual flow control. The valve is adjustable from the refuelling floor with the reactor at pressure.

(7) *Canned circulator*

The circulator and driving motor are contained within a pressure-bell forming an extension to the base of the heat-exchanger. This arrangement eliminates the necessity for a rotating gas-seal and additional external duct-work.

Layout of the station

As already mentioned, the reactor will generate 100-MW (heat) and there will be a net electrical output from the station of 28-MW. The station consists of the reactor unit, which is housed within the containment building, the fuel-element building and the turbine house. The fuel-element building contains the clean fuel-element store, and the breakdown and inspection facilities for the irradiated fuel. Between the fuel-element building and the containment building, (situated below ground-level), is the rotary store or carousel for irradiated fuel which is cooled by a closed cycle CO_2 system. To the south of the reactor is the turbine house which houses the turbo-alternator, the full-power dump condenser and the diesel generators which supply stand-by power. At the northern end of the turbine house and integral with it, is the control block which contains the switch-room, stand-by batteries, motor alternator sets for instrumentation and control, the main reactor and electrical control rooms, and the change-rooms adjacent to the personnel airlock giving access to the containment building. Along the west wall of the turbine house is the administration wing. This arrangement gives close control for the complete station, with the control rooms adjacent to the containment building, the power group and the administrative staff.

Externally, to the east, are the induced-draught cooling towers associated with the turbine and the carbon-dioxide storage and evaporation plant. To the west, is the electrical sub-station for the export of power, the buildings housing the containment ventilation plant, and the motor-alternators associated with the five loop systems.

Description of the reactor

The vertical reactor is designed for a working pressure of 300 lb./sq. in. for inlet temperatures to the reactor of 250-325 deg. C. and outlet temperatures of 500-575 deg. C. Initially, operation will be at the lower-end of these ranges. The graphite core and reflector are contained within a cylindrical pressure-vessel, 21 ft. internal diameter, with hemispherical ends, giving an overall height of 60 ft. It is lined along the barrel by a 6-in. thick mild-steel thermal shield. The pressure-vessel which was constructed by Whessoe Limited, Darlington, is constructed with $2\frac{7}{8}$ in. thick steel plates in its cylindrical portion, but several special features of the vessel required the use of plates of up to $3\frac{7}{8}$-in. thick in the top-

end, and up to $4\frac{3}{8}$-in. thick at certain points in the cylindrical portion. There are 253 branches in the top dome, each corresponding to a channel in the core and arranged on a $10\frac{3}{4}$-in. triangular lattice pitch.

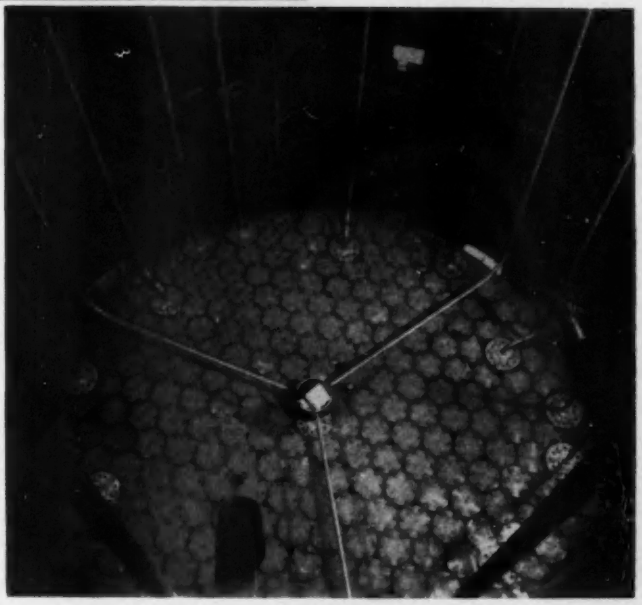
Four CO_2 circulators and heat-exchangers are installed, principally for safety reasons. These main circulators, which control the circulation of the CO_2 through both the reactor and heat-exchanger vessels, were designed and manufactured by James Howden & Co. Ltd. Each unit consists of a Howden "Aerofoil" centrifugal circulator of extremely high efficiency, specially adapted for this application. Each circulator, although only 36-in. dia., absorbs 1,520 h.p., and raises the CO_2 pressure by 28 lb./sq. in. Unique features of the circulators are that the driving motors, manufactured by Laurence Scott & Electromotors Limited, are contained within Class 1 pressure-vessels which are attached to the main heat-exchanger pressure vessels and form an integral part of the high-pressure circuit. The motors, which are of vertical-spindle design, have special insulation and sleeve and thrust bearings designed to operate entirely immersed in the high-pressure CO_2. The main motors run at constant speed, and control of the circulator output is obtained by a specially-designed high-duty Howden inlet vane mechanism. Output control over the complete range of possible duties can, by this means, be obtained without stall or surge, and with high efficiency. The mechanism of the vane control required very special design considerations due to the arduous conditions of high temperature, extremely dry environment and the necessity for avoiding the use of lubricants of any sort. All the pressure-vessels, cooling, locking and control devices for these units were designed and supplied by Howdens.

The unusual principle of using submerged motors and bearings, avoids the need for rotating shaft seals, and eliminates the danger of CO_2 leakage from the reactor circuit. The difficulties of maintenance of the motors and bearings have been overcome by a design feature which allows the motors to be entirely removed and examined without depressurising the main CO_2 circuit; thus advantages of the submerged system are obtained with little sacrifice in accessibility to the rotating mechanism.

The reactor vessel is supported at the upper end of the barrel section on the same level as the gas-ducts, thus eliminating vertical expansion problems and allowing short rigid concentric ducts to be fitted between the reactor and the heat-exchangers. The latter are supported at the same level and move bodily on ball-bearing supports in a radial direction with respect to the reactor centre line. Differential expansion between the inner and outer ducts is accommodated by a bellows unit at the heat-exchanger end of the inner duct. Isolating butterfly valves in the inlet and outlet gas-lines are fitted inside the bases of the heat-exchangers, with remote operation through the pressure shell.

Flow is upwards through the reactor and the heat-exchanger tube banks; the economiser is, therefore, located at the top. This gives enhanced natural convection on the gas-side under fault conditions, and it is possible to direct mains water through the economiser tubes to increase

(Above). General view of the site showing the 148-ft. high by 135-ft. dia. welded-steel containment building under construction to house the advanced gas-cooled reactor (A.G.R.).



(Right). Top dome of the reactor pressure-vessel with refuelling branch nozzles welded in position.

this effect under major fault conditions. After passing over the tube banks, the coolant flows down the spaces between the banks and the pressure-shell into the circulator inlet, and then via the annulus between the two ducts to the reactor vessel where it cools the shell before flowing upwards through the core. Particular attention has been given to leak tightness of the pressure circuit. Butt-welds are incorporated wherever possible, flanges are seal welded, and the smaller valves have bellows type seals.

Temperature and pressure effects are divorced in the re-entrant principle for gas flow which has been adopted. The full pressure is taken by the external shell, with the internal shell taking only the differential pressure of 28 lb./sq. in. which is provided by the circulator to give the necessary mass flow. Both the inner and outer shells operate at the inlet temperature (325 deg. C. maximum) since the former is insulated on the hot-side by laminar crimped stainless-steel sheets. The insulation extends from the inlet gas manifold within the reactor vessel, through the inner of the concentric ducts, to and through the heat-exchanger.

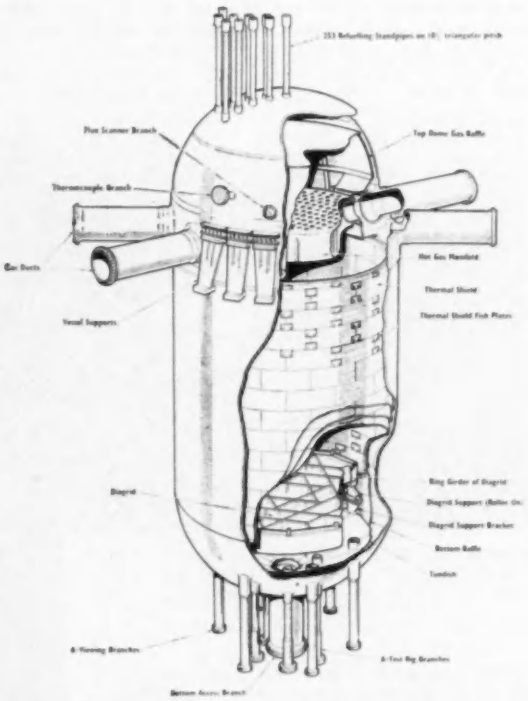
The graphite structure is non-compensated and is of solid construction, i.e., each brick is in contact with its neighbours. It is mounted on ball-bearings and restrained by circumferential steel garters; the ball-bearings sit on support plates on the diagrid structure. The diagrid is supported on brackets with intermediate rockers to allow differential expansion between the grid and the reactor shell. Beneath the grid is a tundish 3-in., thick, which serves as a thermal shield and also would direct anything breaking loose in the reactor to a central pot from which it could be removed on reactor shut-down. In addition to the branches associated with the five loop systems, there are viewing branches to facilitate inspection of the base of the reactor by remote means, including a television camera.

The reactor is designed to be refuelled on load—the single refuelling machine having two main systems mounted on a crab and gantry structure giving complete coverage of the refuelling face. The normal handling facility is for refuelling on load and at pressure. It is shielded, and incorporates a cooling circuit. The special system permits emergency functions to be carried out with the reactor off power and depressurised. The machine also removes or replaces control rods and mechanisms, emergency shut-down devices, and graphite-sampling equipment. It also serves the five loop systems. The machine weighs some 400 tons and is 60-ft. in overall height.

New fuel elements pass from the fuel-element building through the " clean way in " to the containment building, where they are attached to the fuel plug string and the instrument connections are made. The assembly is then lifted into the clean zone of the normal handling facility in the refuelling machine, from which it is charged into the reactor. On discharge, the fuel-element is cooled continuously, initially by the reactor coolant, but at a later stage in withdrawal the refuelling machine takes over until the fuel-element is actually sealed within the refuelling machine. The fuel plug string is transferred from the refuelling machine to a transit facility. The fuel elements are detached and lowered into the carousel where the activity is allowed to decay. They are then lifted into the adjoining fuel-element building for either metallurgical examination or breakdown prior to subsequent chemical treatment.

Control of the reactor has demanded considerable attention because of its advanced nature. The theoretical work is supplemented by exponential and other sub-critical experiments to establish the neutron behaviour in clusters of oxide rods in beryllium cans. This experimental work is done at the Winfrith Heath Laboratories of the Research Group. Eventually, the A.G.R. will yield data on control and burn-up effects, whilst the HERO zero energy reactor will give detailed information at various temperatures and facilitate interpretation of the A.G.R. results.

The reactor is controlled in a conventional manner by boron steel rods suspended from the control mechanisms



Cut-away drawing of the 21-ft. dia., by 60-ft. high welded-steel pressure vessel constructed by Whessoe Limited for the advanced gas-cooled reactor.

which are housed entirely within the refuelling branches in order to give clear access to the refuelling face. Fuel and control rods are interchangeable so far as access to the core is concerned. Besides the normal control equipment, secondary shut-down devices actuated by a rise in fuel temperatures, permit boron steel balls to be injected into tubes within the reactor to give shut-down. Three separate lines are fitted, with different routes to the control room, for all safety circuits, and a two-out-of-three system has been adopted for actuation of the reactor trips. The five loops consist of tubes which pass right through the core and which are sealed from the main coolant circuit at each end of the reactor vessel. Each loop has a completely separate coolant circulation and heat removal system which is housed immediately out-

board of the biological shield at basement-level. Each is contained in a separate cell forming an extension to the inner containment. Again a re-entrant principle has been adopted, flow is upwards past the fuel-elements and down in the concentric annulus. Particular attention has been given to the design and safety features of the loops to ensure that their integrity is not less than that of the reactor. They are designed to enable advanced experiments to be carried out which may, in some cases, result in coolant contamination with fission products which would be undesirable in the main coolant circuit. The loops will also enable experiments to be carried out at temperatures different from those in the main reactor system, and with different coolant gas compositions, i.e., variation in the carbon monoxide content. It will be possible to test advanced types of fuel elements and also to determine their ultimate limitations.

Box girder struts are used to support the preformed steel plates during the fabrication on site by Babcock & Wilcox Limited, of the reactor containment vessel or building, which houses the reactor, the four heat-exchangers, main gas-circulators and refuelling machine

Containment building

In view of the experimental nature of the reactor, it is enclosed in a steel containment building constructed by Babcock & Wilcox Limited. This building consists of a lower conical section surmounted by a hemisphere. It is 70 ft. dia. at the base and 135-ft. dia. at the equator. The building will contain the entire contents of the reactor pressure-circuit in the unlikely event of a breach of the latter. It is designed for a pressure of 10 lb./sq. in. g. and it is to be tested to 12.5 lb./sq. in. g. Vacuum relief valves are fitted to limit the negative pressure due to atmospheric variation to 0.25 lb./sq. in. g. The three airlocks provide access for:—(1) Personnel between the refuelling floor and the control annexe of the turbine house. (2) Goods at ground level, and in particular for maintenance of such items as the circulators, and (3) emergency exit from the refuelling floor.

The building is lagged externally, and is ventilated to maintain a differential of 2-in. positive pressure between the working areas of the building and the inner containment provided by the biological shields surrounding the reactor vessel and heat-exchangers. The building is also air-conditioned in the working spaces, and a separate cooling system is installed for rejection of the heat liberated within the structural materials of the inner containment and arising from heat loss through the lagging of the pressure-shell. The air is finally discharged through scrubbing towers to the 200 ft. high stack. Other gaseous discharges from the containment building during normal operation, i.e., blow-down, and under accident conditions such as relief valve blow-off or rupture of the pressure circuit, are vented to a chemical plant consisting of heat sink, filters and an activated carbon absorption pack prior to discharge from the stack.

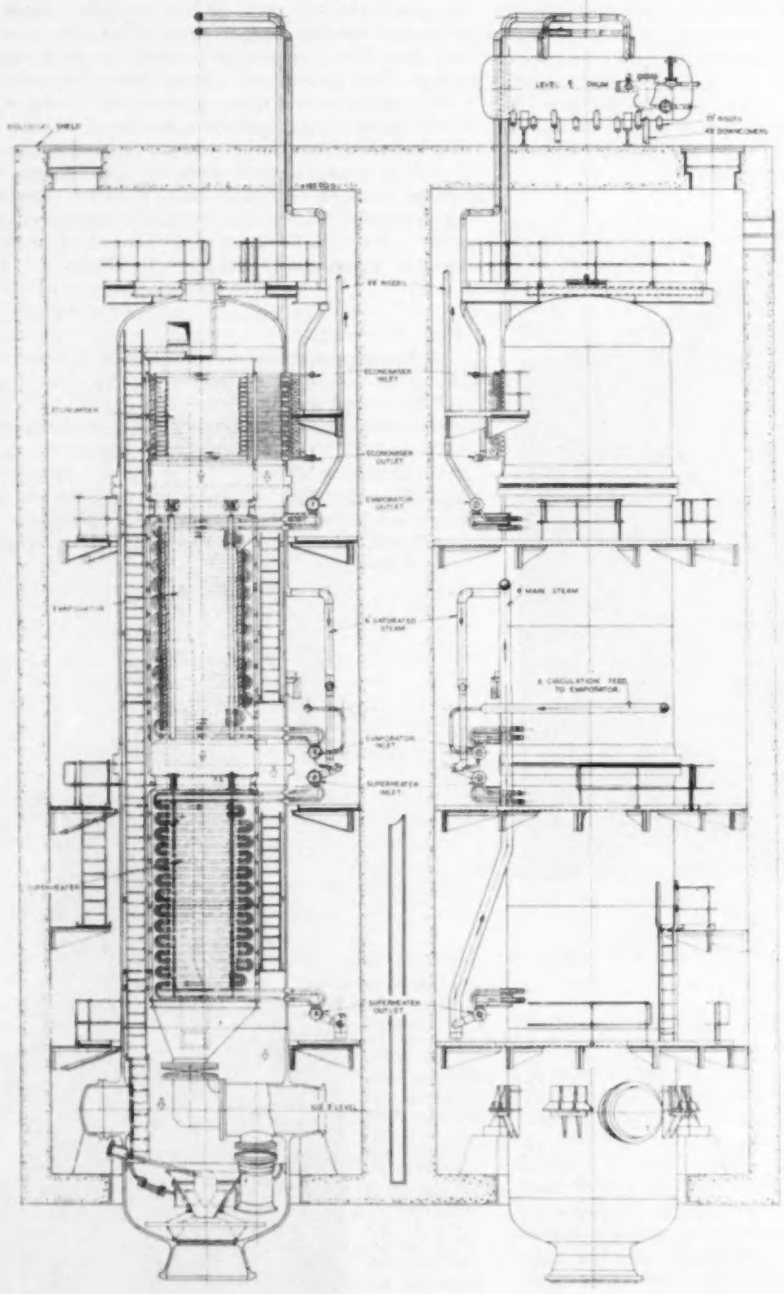
Heat exchangers

Steam is generated in the heat-exchangers at 650 lb./sq. in. and 454 deg. C. (850 deg. F.), stop-valve conditions. A 900 lb./sq. in., 483 deg. C. (900 deg. F.) system would have been possible, but this would not have been as flexible for experimental purposes as the lower pressure system adopted. Electricity is generated in a 33-MW turbo-alternator manufactured by the English Electric Co. Ltd., and there is also a full-capacity dump condenser, designed and manufactured by Hick, Har-

The four heat-exchangers, the shells of which are 11-ft. dia. by 70-ft. high, were constructed by International Combustion Limited. Two sections of one of the heat exchangers are seen being lifted over the containment vessel.

greaves & Co. Ltd., which can be used to reject the reactor heat load if the turbine is out of commission.

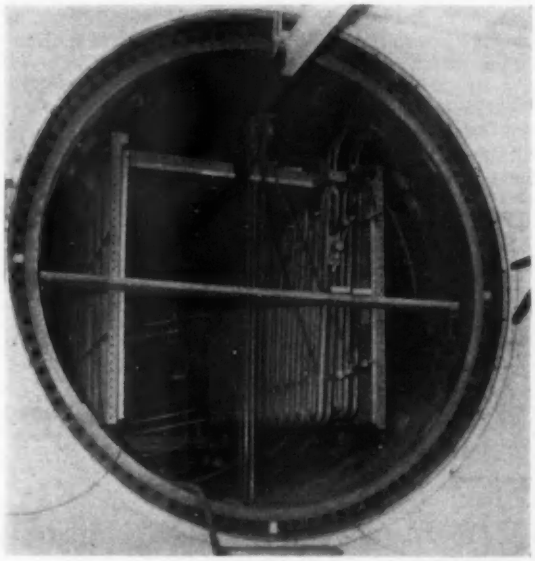
The four heat-exchangers designed and manufactured by International Combustion Limited are capable of generating 78,350 lb./hr. of steam. Each exchanger comprises a shell 11 ft. 0 in. dia. and about 70 ft. 0 in. high, manufactured in three sections, housing respectively the economiser, evaporator and superheater, and centrifugal blower, which is mounted in the bottom head. The basic philosophy in the design of the pressure circuit has been to segregate as far as possible, pressure and high temperature. On the heat-exchangers and ducting, this has resulted in the hot gases leaving the reactor through the inner legs of concentric ducts. The gases rise vertically through the heating surface of each exchanger which is housed in a square section casing,



Outline arrangement of a pair of heat-exchangers, one of which is shown in section. Each heat exchanger is enclosed by a biological shield of concrete, the two shields being joined between each pair of exchangers. Each unit is capable of generating 78,350 lb./hr. of steam at 660 lb./sq. in. and 860 deg. F. The heat-exchangers were designed and constructed by International Combustion Limited.

and it is not until they are fully-cooled at the exit of this section that they come into contact with the main pressure-shell. The gases are then passed downwards in the annulus between the main shell and the rectangular casing, connected to the circulator eye, and discharged to the outer annular duct for return to the reactor. This design has avoided the need to use expensive high-temperature resistant alloy-steels in the main pressure-circuit, and the outer sections of the exchangers and ducting are manufactured from low carbon manganese steel, combining a low notch ductile transition temperature with adequate creep properties. The heating surface of each exchanger totals 47,000 sq. ft. The economiser and evaporator sections are manufactured from Tube Products' 2-in. o.d. mild-steel resistance-welded tubing with $\frac{1}{2}$-in. high helical fins welded externally with six fins per inch. The superheater elements are manufactured from plain $2\frac{1}{4}$ per cent. chrome/1 per cent. moly. tubing.

Forced-circulation is adopted—two Hayward Tyler glandless circulating-pumps being fitted in each circuit. Advantage was taken in manufacture to complete each shell section at the company's works at Derby in a special "clean conditions" shop in which the elements and internal casings support, galleries, etc., were fitted prior to despatch to site. The shell sections were joined together after erection by means of seal welded flanges.

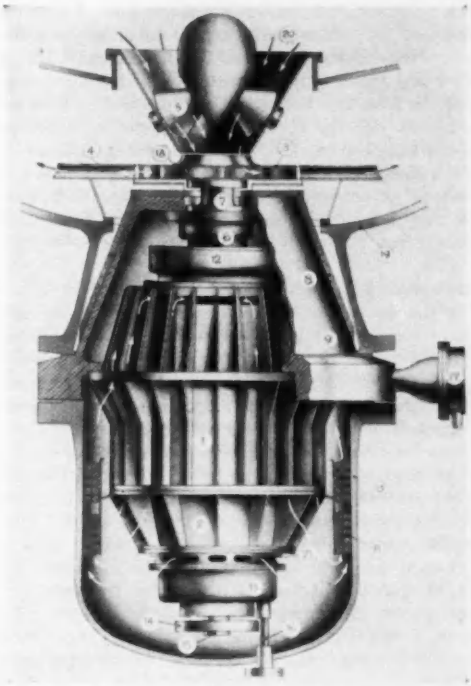


Interior of one of the four heat-exchangers, showing superheater sections being tubed up in "clean conditions."

The weight of the heaviest section was 90 tons. To provide for thermal expansion, the exchangers are each mounted on ball-bearing systems, supported on six plinths. This allows the exchangers to move radially with respect to the centre-line of the reactor vessel.

Turbo-alternator

The turbo-alternator, manufactured by the English Electric Co. Ltd., is a 33-MW machine operating at 3,000 r.p.m. and generating at 11.5-kV. The turbine is of the company's standard two-cylinder design with single-flow high-pressure cylinder of the impulse type. The low-pressure cylinder is of the double-flow outwards reaction type with the exception of the first-stage in each



Cut-away view of one of the four main CO_2 circulators which were made by James Howden & Co. Ltd.

Key:—

1—Main motor, 1,570 h.p., 2,970 r.p.m. constant speed (Laurence Scott & Electromotors Ltd.). 2—Pony motor, 40 h.p.—speed variable from 600 r.p.m. to 1,800 r.p.m. Operated from variable frequency constant power control system. 3—Howden high efficiency aerofoil bladed radial flow impeller. 4—Vaned diffuser. 5—Variable inlet control vanes. 6—Standstill seal. 7—Stub shaft. 8—Stainless steel insulation. 9—Pressure vessel. 10—Removable pressure bell. 11—Motor cooler. 12—Michell journal bearing with oil bath lubrication and submerged cooler. 13—Michell journal and thrust bearing with oil-bath lubrication and submerged cooler. 14—Rotor brake. 15—Impeller removal device. 16—Standstill seal operating spindle. 17—Terminal box. 18—Heat trap. 19—Main heat-exchanger vessel. 20—Main CO_2 circuit. 21—Motor cooling circuit.

flow which is of the impulse type. The steam pressure at the turbine stop valve is 650 lb./sq. in. with a temperature of 850 deg. F. The vacuum at the continuous maximum rating is 28.6 in. Hg. (Bar 30 in.) with a final feed temperature of 350 deg. F. The alternator is a standard English Electric air-cooled machine with separate motor-driven fans. Excitation is provided by a totally-enclosed air-cooled exciter driven from the tail shaft of the alternator through a flexible coupling. It uses magnetic amplifier automatic voltage regulators.

The feed-heating scheme is of the four-stage type comprising one low-pressure heater, two half-duty high-level de-aerators, and two banks of high-pressure heaters,

both of which are arranged with two half-duty heaters. In addition, a drain cooler is arranged on the suction side of the boiler feed-pump between the air ejector and the low-pressure heater. The feed heating system is designed to raise the temperature of the condensate to 350 deg. F. at the maximum continuous economic load, by means of steam bled from four points on the turbine when the set is operating under the specified conditions. The h.p. heaters are suitable for heating feedwater by means of live steam from the boiler as an alternative to bled steam heating, to suit the special requirements of the reactor heat-exchange system. The condensing plant is of English Electric standard twin-shell design, with a total surface of 31,800 sq. ft. Circulating-water temperature is 68 deg. F. and the total C.W. quantity to condenser 24,500 g.p.m.

Switchgear and control gear

For the control of the power supplied to the power station, auxiliary and the advanced gas-cooled reactor services, English Electric (Liverpool) are supplying two 14-panel 150-MWA 3.3-kW switchboards, with associated control boards and bus-zone protection equipment.

English Electric Company's data Processing & Control Systems Division, at Kidsgrove, are supplying temperature scanning equipment based on their new "Datapac" logical elements. The equipment will be used to monitor the vital temperatures in the advanced gas-cooled reactor including those of the fuel cans, the concrete shielding, the coolant gas and the graphite. In all some 1,250 thermocouples will be used to measure temperatures at critical points in the reactors; of these, about 250 will provide a representative sample of the temperatures of the new fuel cans, 200 will be used to record the coolant gas temperatures at the outlets of fuel channels in the graphite moderator block, 250 will measure temperatures in the graphite itself, while the remainder will be distributed to measure temperatures of such important components as the biological shield and other vital structural items.

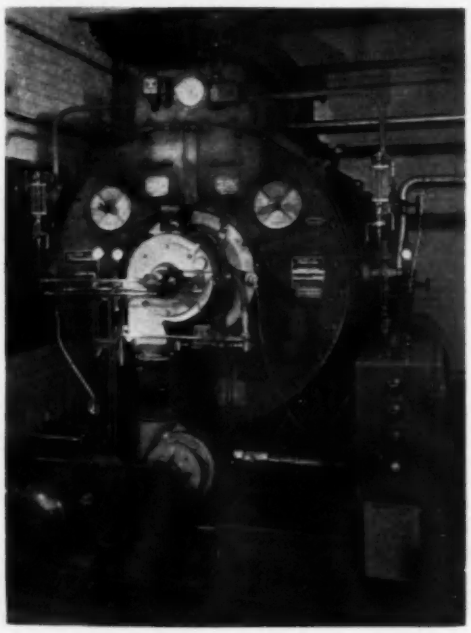
Pipework

The pipework engineering division of Stewarts and Lloyds Limited is responsible for the two main piping contracts for the installation. The first contract covers the main steam, feedwater, carbon-dioxide gas and other associated pipework, and the second is for the general cooling and process pipework in the reactor and turbine house. The main steam pipework is of 1 per cent. chrome, ½ per cent. molybdenum alloy steel, and designed for service at 660 lb./sq. in. and 860 deg. F. The high-pressure feed range is manufactured in mild-steel seamless tube, for service at 900 lb./sq. in. and 350 deg. F. The carbon-dioxide gas-piping to and from the reactor heat-exchangers is designed to withstand a pressure of 300 lb./sq. in. at 100 deg. F., while the circuit lines and carbon dioxide exhaust lines operate at 617 deg. F. and the exhaust lines from the safety valves at 750 deg. F. Pipe joints in all the above-mentioned services are of either the buttweld or seal weld type.

The second pipework contract consists of risers in the reactor building, which adjoins 8-in. and 6-in. ring mains 43-ft. and 50-ft. dia. respectively—the joints in this main being of the Viking Johnson coupling type. From the ring main, connections are made either in mild steel or copper pipes to supply water to such equipment as circulators, mortuary, driers, bio-shield cooling plant room and the carbon-dioxide storage room. In the turbine house, supplies by Stewarts and Lloyds include the 10-in. and 8-in. Mulsifyre mains, 4-in. bore dry riser, and subsidiary circuit pipework which is in mild-steel with buttwelded or flanged joints.

PACKAGED BOILER REDUCES DAIRY STEAM COST

The steam supply for the Stratford Dairy Limited, establishment at Stratford, Warwicks., was originally provided by two vertical cross-tube solid-fuel-fired boilers, consuming, on average, 1-ton per day of coke. Output and pressures were below that required, and considerable expense was incurred for a full-time stoker and for transport to remove boiler ash. Subsequently, a Model "80" "Powermaster" oil-fired packaged boiler was supplied and installed by G.W.B. Furnaces Limited, and this unit has proved to be dependable, while at the same time resulting in an appreciable saving in running costs. As the packaged boiler is fully-automatic, the stoker has been transferred to other duties in the dairy, and now the occasional visual checks and maintenance which are required are carried out by the plant maintenance engineers. An automatic time switch switches the boiler on at 6.45 a.m., and the steam supply is available each morning as soon as work commences. The Model "80" has an output of 2,760-lb./hr., from and at 212 deg. F., which is more than sufficient to meet the present demands of the dairy, and plans are in hand to extend the steam usage to cover space heating of the office block, where electrical heating is at present employed. The Powermaster is equipped with a Voriflow fully-modulating burner, and is, therefore, able to meet changing loads by automatically regulating the supplies of fuel and air to the burner. Modulation takes place down to 20 per cent. of boiler output and, since only the correct amount of fuel is burned for each load, high efficiencies are obtained. Previously, trouble was experienced when such equipment as the churn washing machines were switched on and the vertical boilers could not meet the sudden increased requirements. It is estimated by the company that the Powermaster boiler is saving almost £1,500 a year in fuel costs alone.



Fluidrive for Boiler Feed Pumps

THE first boiler feed pump to be driven by a Vulcan-Sinclair infinitely-variable-speed fluid coupling, was installed at the Greenwich Power Station in 1931. During the 29 years which have elapsed since then, many hundreds of such couplings in power ratings up to 3,000 h.p. have been put into service and units of ratings up to 8,000 h.p. are under construction. While considerable numbers of boiler feed-pumps have been equipped with fluid couplings made by Fluidrive Engineering Co. Ltd., Isleworth, many more at the present time are in service in the U.S.A.; these fluid couplings, having been constructed by the American Blower Corporation, the Vulcan-Sinclair licensees, and have largely become standard practice for boiler feed pumps drives in America.

In Europe, nevertheless, with the rapid trend in recent years towards extra large capacity boilers, and the use of feed-pumps with a rising head characteristic of up to 15 per cent., the fluid coupling is also rapidly becoming accepted as the most satisfactory means of driving this type of pump. With the high cost of fuel, and of operating costs generally, saving in power continues to be of increasing importance. Thus, by automatically varying the speed of the feed-pump to match the boiler load requirements, instead of throttling the output, and by enabling the pump to operate at the optimum efficiency, experience has established that a saving in power of 10 to 15 per cent. is achieved. Consequently, "Fluidrive" has now been used for many years in conjunction with constant-speed squirrel-cage motion, for speed control of boiler feed pumps, this combination completely satisfying the requirements of simplicity, efficiency, reliability and low initial cost.

In the past it has been common practice to operate the pump at constant speed, regulating its discharge by means of a throttle valve. Hence, at light loads and under starting conditions, high-pressure drops were created across the regulator valve, due to the rising head characteristic of the pump. The presence of design margins and the requirement that the pump be designed to feed the boiler at 80/100 per cent. full flow entails that, even at turbine m.c.r., an appreciable pressure drop may still obtain across the valve. This pressure drop results in a waste of power, causes erosion trouble and subjects the feed-heaters and piping to unnecessarily high-pressures. The use of a squirrel-cage motor and variable-speed fluid coupling enables the pump output to be matched precisely to the boiler requirements. One of the most modern Dutch installations at the P.L.E.M. power station at Buggenum, comprising three full-duty feed-pump units for an 85-MW turbo-alternator set is illustrated in Fig. 1. Each equipment comprises a 3,200 h.p., 2,970 r.p.m. Harland squirrel-cage motor, with size 22½ type DST Vulcan-Sinclair fluid coupling driving through step-up gearing to a Harland compensated type boiler feed pump, designed for a maximum speed of 4,700 r.p.m. Also at this station, are four size 18 single-circuit scoop-trim fluid couplings on earlier feed-pump sets rated at 730 h.p. at a speed of 2,950 r.p.m.

A range of fluid couplings of the scoop-trim type have been specially-developed for operating with two-pole squirrel-cage motors for boiler feed-pump duties. For the lower ratings, these are of the single-circuit type, whilst for the higher powers, a range of double-circuit couplings has been developed. An example of one of the couplings from the latter range, namely, a size 20 DST fluid coupling, is shown in Fig. 2. From the illustration it will be seen that the DST design generally follows boiler feed-pump construction, the rotating parts being carried within a separate barrel, supported at its centre line from a substantial cast-iron base-plate. This arrangement gives great rigidity and freedom from thermal expansion effects. The illustration emphasises the self-contained nature of the fluid coupling and shows also the control lever for attachment to the automatic control servo-cylinder.

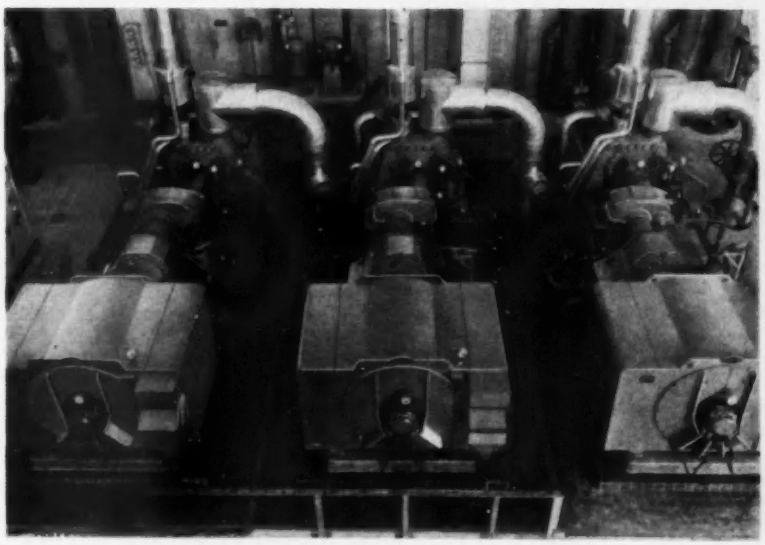


Fig. 1. One of the most modern Dutch installations at the P.L.E.M. power station at Buggenum—comprising three full-duty feed-pump units for an 85-MW turbo-alternator set.

Typical head/quantity characteristics

A typical head/quantity characteristic for a large boiler feed-pump operating at constant speed is shown in Fig. 3. together with a boiler system resistance curve. This

curve shows the effect of a high static head, represented mainly by the boiler drum pressure, plus the frictional resistance of the feed piping. Fragments of the pump characteristic under variable speed conditions are shown at their intersections with the system resistance curve, and it will be seen that, due to the high static head prevailing, a speed range of only 17 per cent. is sufficient to meet all requirements from pump design point down to zero flow conditions. At turbine m.c.r., the pump runs at about 96 per cent. of full speed, this speed reduction representing in effect, the various margins allowed for in the system.

When the pump is employed as a constant-speed unit, current practice is to arrange for the feed pump to have a head rise between design point and shut-in of about 15 per cent. If the pump is designed to operate under variable speed conditions, however, this head rise is often increased to about 20 per cent.

The advantages of so doing are three-fold—firstly, the point of maximum pump efficiency coincides with 100 per cent. m.c.r. flow and, secondly, the steeper characteristic assists the operation in parallel of two similar pumps at any required speed. This latter point is important in the case of half-duty main feed-pumps, where it may be required to operate one unit at constant speed, carrying out the flow regulation by varying the speed of the second

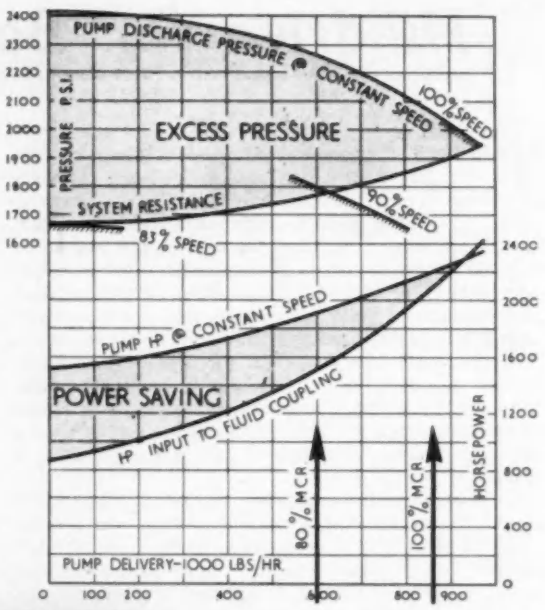


Fig. 3 (above). Typical head/quantity characteristic for a large boiler feed pump running at constant speed, together with a boiler system resistance curve.

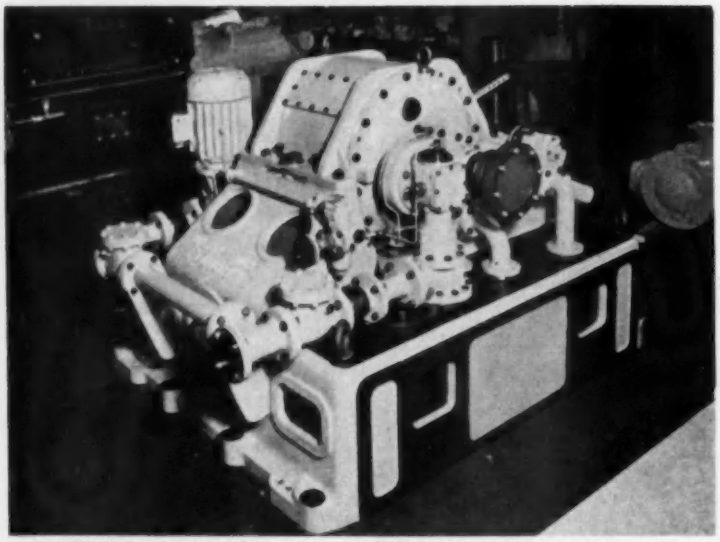


Fig. 2 (left). A size 20 DST fluid coupling from the range of scoop trim couplings specially developed for operating with two-pole squirrel-cage motors for driving boiler feed pumps of large output capacity.

unit. Thirdly, it should also be noted that, in general, the maximum efficiency of the feed pump tends to be higher for a greater permissible rise in head between design point and shut-in.

In the lower part of Fig. 3 the horsepower demand of the feed pump at constant speed is shown plotted against the corresponding horsepower input to a fluid coupling-variable-speed feed-pump. It will be seen that, other than in the region of the pump design point, there is a substantial saving of power, which increases with reduction in turbine load. As noted above, the pump design point generally corresponds to feeding the boiler at 80/100 per cent. of full flow under blow-off conditions, and is, therefore, not a normal operating condition. With a load factor that would generally be applicable during the early life of a modern plant, it can be assumed that operation will be within the limits of 80-100 per cent. m.c.r., as indicated on the graph, but operation will also take place for limited periods at lighter load conditions, at which time the power saving will be greater.

In general, it has been established that an average saving in power of about 10-15 per cent. is achieved by using Fluidrive for the feed pumps.

One of the boiler feed-pump sets being supplied by G. & J. Weir Limited for the Richard L. Hearn Power Station in Toronto, Canada, is shown in Fig. 4. Each drive unit for these half-duty feed-pump sets comprises a 3,000 h.p. at 3,550 r.p.m. squirrel-cage motor and size 20 DST variable-speed fluid coupling. Six such sets have been supplied for the 200-MW turbo-alternator sets Nos. 6 and 7, whilst a further three similar sets have been supplied for unit No. 8 by the Harland Engineering Co. Ltd., Alloa.

In general, a fluid coupling is capable of giving a speed regulation range of about 5 : 1 against a centrifugal resistance law, although, as noted earlier, against a boiler resistance load containing a high degree of static head, a speed range down to only about 75 per cent. of full speed is all that is required. The facility for obtaining

very low pump speeds is, however, particularly valuable for boiler filling purposes, and also during boiler starting and boiler trimming periods.

Fluid couplings are entirely suitable for operation with any of the standard forms of automatic control. In general, this control is of the three-element type, responding to changes in feed flow to boiler and steam flow to turbine, with an overriding impulse from the boiler water drum-level. The regulator, if fitted, is frequently arranged for sequential control, so that the early part of the three-element operation moves the regulator valve to the fully-open position, thereafter all control being carried out on the fluid coupling. Many of the newer power stations on the North American continent take this development a stage further, omitting the regulator valve entirely.

Type ST fluid coupling

Two size 18 scoop-trim fluid couplings, with Gordon automatic control, driving two full duty feed pump sets serving the 125 T.P.H. boilers at Vlissingen (Flushing) Power Station in Holland are shown in Fig. 5. This installation is of considerable interest in that, originally, it was intended to regulate the boiler water-level by automatically controlled feedwater regulating valves. It was found, however, that the speed response of the fluid coupling was so rapid and accurate that the water-level could be maintained constant simply by varying the speed of the duty feed-pump, whilst leaving the regulator valve fully-open. Consequently, the regulator valves are now only used under start-up conditions, otherwise complete control of feed flow is effected by the fluid couplings.

The foregoing example illustrates the rapidity of control achieved with a fluid coupling, a contributing factor being the extremely low moment of inertia of the fluid coupling secondary parts directly connected to the feed pump. Generally, the secondary parts of the fluid coupling are equivalent to less than 5 per cent. of the driving motor rotor inertia, and hence acceleration and deceleration time lags are eliminated.

(Right). One of six 3,000 h.p. boiler feed pump sets made by G. & J. Weir Limited, with size 20 D.S.T. Fluidrive, for the Hydro-Electric Power Commission of Ontario's Richard L. Hearn generating station.

The pump set is often required to start up under reduced voltage conditions on the motor, usually 75/80 per cent. full volts are a specified requirement. The presence of a fluid coupling ensures that the motor will essentially "run up" to speed before any appreciable torque is transmitted by the fluid coupling, and hence there is no risk of a motor "crawling" condition arising. This property is particularly valuable in the case of reduced voltage starts referred to above. With a split pumping scheme, i.e., booster pump and main pump, it is common practice at start-up for the two motors to be switched on together. With a fluid coupling incorporated in the drive to the main pump, a controlled start is thus available. Hence, the actual start of the main unit may be delayed until the booster pump has generated a pressure in excess of the feed vapour pressure, thus allowing the main pump to start up without cavitation conditions at its suction.

The advantages of Fluidrive can thus be summarised as follows:—

(1) No regulator throttling losses or erosion troubles.
(2) Maximum pump efficiency and optimum pump design.
(3) Lower high-pressure heater and feed piping operating pressure.
(4) Reduced plant maintenance.
(5) Fluid coupling completely self-contained, requiring only a simple water-operated oil cooler.
(6) Entirely suitable for any standard form of automatic control.
(7) Light load starting of driving motor and controlled start of pump available if required.
(8) Low pump-speed available for boiler filling and starting duties.

Recent development

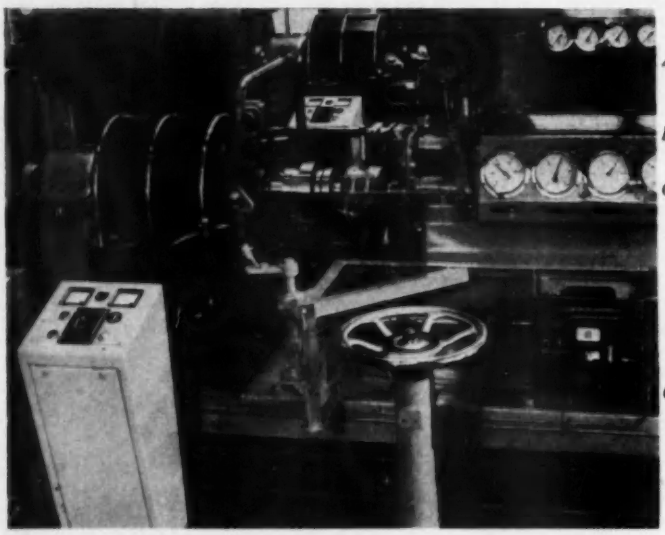
One of the latest contracts received for Fluidrive for boiler feed pump regulation concerns the two 275-MW turbo-alternators being constructed by the English Electric Co. Ltd. for the new C.E.G.B. station at Blyth "B." (North Eastern Division). Each turbine and boiler will, of course, operate on the unit system, and the main feed-pump unit will be driven from the tail-end of the turbo-alternator shaft through a size 24.5 double-circuit type scoop-trim fluid coupling. In this way the capital cost of driving motors, switch gear and electric cabling is eliminated. Likewise, the losses inherent in generation and reconversion of the electrical energy into mechanical power are also saved.

Reference should here be made to the extensive experience of the Fluidrive Engineering Company's American co-licensees—American-Standard Industrial Division, in the boiler feed pump regulation field, where they have more than 800 variable speed scoop-trim type fluid couplings in operation. Furthermore, they have over 20 units in operation, or on order, for feed pump drives from the tail-end of the turbo-alternator shaft, as referred to above, in powers up to 12,000 h.p., thus, for driving some of the largest boiler feed pumps in the world.

Type STD fluid coupling

A new range of high-power single-circuit scoop-trim

fluid couplings for operation with four- or six-pole squirrel-cage motors is available. This range is based on the principles in the type ST5 (3,000 r.p.m.) range of coupling, of which a large number have been in service for many years. Furthermore, in order to achieve the optimum efficiency, pump speeds in excess of 3,000 or 3,600 r.p.m. are often required. The new range of fluid couplings, running in conjunction with step-up gears, provides a variable-speed pump drive with the lowest possible initial cost and maximum overall efficiency.



Fluidrive Engineering Co. Ltd. have recently received the order from Hathorn Davey & Co. Ltd., of Leeds, for six size-41 type-STD fluid couplings, each rated at 3,300 h.p. at 1,480 r.p.m. These variable-speed fluid couplings are required for the two 200-MW sets being constructed for the Kincardine "B" Station of the South of Scotland Electricity Board. They will operate with squirrel-cage motors, and drive through Allen-Stoeckicht step-up gears to the 50 per cent. duty boiler feed-pumps, of which there are three per boiler.

It may be of interest to mention here some of the more recent power stations in which Fluidrive has been installed for feed-pump control, together with some notable examples for which Fluidrive is on order. From the following list, it will be seen that there are some of the largest and most important stations, in several different countries.

Australia
Tallawarra
Tennyson

Belgium
Droogenbosch

Canada
Richard L. Hearn
Lakeview
New Brunswick
Thunder Bay

Finland
Pargus Kalksbergs
Enso Gutzeit

Great Britain
Lincoln
I.C.I. Wilton
Skelton Grange
Barking "B"

Great Britain (continued)
Coolkeeragh
Padiham "B"
Blyth "B"
Braehead
High Marnham
Kincardine

Holland
Amsterdam Noord
The Hague
Hengelo
Maascentrale-Buggenum
Mine "Emma," Dutch State Mines
Nijmegen
Zwolle
Vlissingen
Lage Weide-Utrecht
Leeuwarden

South Africa
Colenso

In conclusion, we acknowledge our indebtedness to Fluidrive Engineering Co. Ltd., for permission to publish this article, and to Mr. J. Elderton, B.Sc., A.M.I.Mech.E., one of the company's senior engineers, for supplying much of the technical data.

CAMBRIDGE INSTRUMENT CO. LTD.

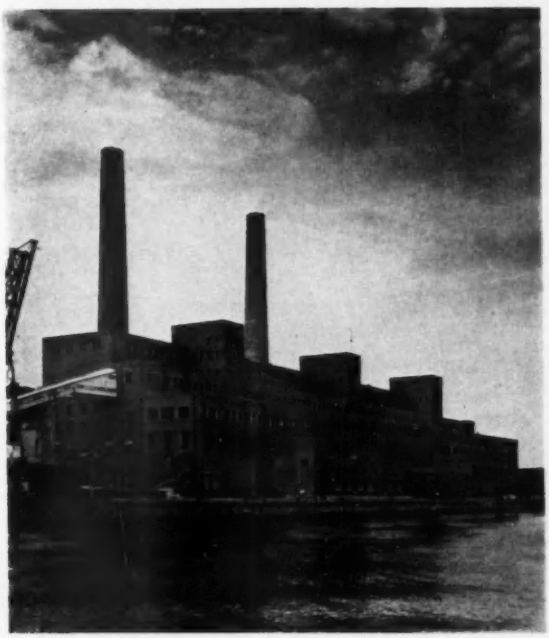
Cambridge Instrument Co. Ltd. recently held receptions on two consecutive evenings, to mark the completion of the enlargement and modernisation of their new Head Offices and Showrooms in London. Situated at the Company's existing address:—13, Grosvenor Place, London, S.W.1, and known as "Cambridge House," the completion of the new offices marks another stage in the expansion programme introduced by the Company to meet the increasing demand for Cambridge measuring instruments, etc. It has enabled the Company to enlarge their sales, publicity, and administrative departments, and thus, to improve their service to instrument users in this country and overseas. Additional accommodation is thus provided for the staff necessary to deal with the additional business, resulting from the present expansion of research and production facilities. At the receptions, the visitors were invited individually, and entertained by members of the Cambridge Board of Directors, and the sales and publicity staff. Most of the visitors were scientists and engineers representing industrial and research organisations interested in the Company's products. Several foreign diplomatic delegations were also represented. These receptions were held three weeks after the Cambridge Instrument Company's 36th annual sales conference, which was held at Cambridge, and which extended over three days. This conference brought agents and representatives from as far afield as Australia, Canada and India, as well as from most European countries. In addition, home-based representatives of firms operating in China, India, Egypt and south-east Asia, together with those selling in some eastern European countries, were also present. It was the largest gathering of overseas representatives yet to attend the Cambridge Instrument Company's conference. Delegates were conducted in parties over the whole works and research department of the Company at Cambridge, as well as to the Muswell Hill (London) works, where they were able to see the expansion now in progress there. The delegates were also taken to the Company's mechanical thermometer division at Finchley, where the novel Minican recorder and Numalec controller are in production. Many of the delegates also visited the enlarged premises at Grosvenor Place, S.W.1, and the conference ended with a dinner at the Hotel Rembrandt, which was attended also by the Board of Directors and by some members of the works staffs and the London office sales and publicity staff.

The Central Electricity Generating Board, Southern Project Group, announces the following appointments: **Mr. L. W. G. Mason,** A.M.I.Mech.E., has been appointed resident site engineer for the Board's fifth nuclear power station to be built at Dungeness in Kent; **Mr. M. V. Horsfield,** A.M.I.E.E., has been appointed resident site engineer for Belvedere power station; **Mr. A. Hanlon,** A.M.I.E.E., A.M.I.Mech.E., has been appointed resident site engineer for Northfleet power station; **Mr. S. F. Mogridge,** A.M.I.Mech.E., has been appointed resident site engineer at Bankside "B" power station.

Portishead 'B' Power Station

WHEN, in 1926, the Electricity Commissioners decided upon the construction of a new power station in the Western area, the site chosen was at Portishead on the North Somerset coast, some ten miles by road from Bristol, and on land owned by the Bristol Corporation. The site was a natural choice, as it was served by a railway from the city, there was a nearby dock—also owned by the Corporation, and there was an ample supply of water for condenser cooling requirements. This first power station was the Portishead " A " station—in which the installed generating capacity ultimately reached a total of 240-MW. The construction of Portishead " B," close to the original " A " station, was commenced in 1949, and it is the third new station in the South Western Division of the Central Electricity Generating Board to be commissioned since the electricity supply industry was nationalised in 1948. The first generating set in the " B " station was commissioned in 1955, and the station was completed in December, 1959, with the commissioning of the sixth machine. The station was designed to accommodate six 60-MW turbo-alternators each supplied with steam from two 300,000 lb./hr. boilers. This boiler capacity gave the equivalent of one spare boiler for the whole station. Since installation, however, the turbo-alternators have each been uprated to 65-MW, making the total capacity of the station 390-MW.

The design and construction of the Portishead " B " power station was carried out under the direction of Mr. A. C. Thirtle, A.M.Inst.C.E., A.M.I.E.E., M.Inst.F., then divisional controller, South Western Division (now regional director of the Southern, South Western and South Wales Region), C.E.G.B., assisted by Mr. J. Irlam, Assoc.I.E.E., chief generation engineer (Construction), until the formation of the Southern Project Group in 1957, when he continued to be responsible as project engineer, until his retirement in August, 1959. The final stages of the work have been the responsibility of Mr. H. S. Davidson, T.D., M.I.E.E., divisional controller of the South Western Division, assisted by Mr. H. E. Vickers, M.I.Mech.E., A.M.I.E.E., chief generation engineer, and his staff. Sir William Halcrow & Partners were the civil engineering consultants, but the whole of the mechanical and electrical engineering work was handled by the Divisional Construction Department.



The turbine house, annexe, bunker bay, and boiler house are grouped into one building which is of steel-framed construction, the structural steel being of welded construction, and is encased in brickwork, faced with golden brown engineering bricks. The window frames are of aluminium, set in artificial stonework dressings. Sand-lime and buff facing bricks are used inside the building to give the maximum amount of light. The roofs are of precast-concrete slabs, while floors generally are of *in situ* concrete, overlaid with granolithic concrete, with the exception of the operating-floor which is covered by quarry and adamantine tiles. In the boiler house, open steel flooring is in general use, for light and ventilating considerations. Around the main power station are the concrete-framed ancillary buildings. On the east side are the operations and the welfare blocks, the former housing the laboratory, offices and the main control room, the latter being linked to the operating-floor of the turbine house by a footbridge over a roadway and a section of the transformer pens. On the west side of the station, close to the boiler house wall, are the electrostatic-precipitators. A 20-ft. wide road separates the precipitators and induced-draught fans from the main-flue supporting structure, under which are housed various ancillary departments such as ash pump house, oil store, machine shop, etc. To the north of the main buildings lies the screen house containing the screening equipment for the cooling-water system. Other structures in connection with the coal-handling equipment are sited on the south side of the main buildings. All these have lightweight cladding in the form of asbestos sheeting fixed direct to the steel structure. The twin chimneys, constructed by Chimneys Limited, are sited on the west side of the station; they are 380 ft. above ground level. The top level of these chimneys corresponds to the level of the chimneys of the " A " station, i.e., 410-ft. Ordnance datum. The chimney stools are of reinforced-concrete, and the barrel is of brick construction lined with acid-resisting bricks. The chimneys have an internal diameter tapering from 26-ft. 6-in. to 20-ft., and a wall thickness tapering from 5-ft. 3-in. to 1-ft. 1½-in.

The extremely high tidal range that prevails in the Severn Estuary (the second highest in the world) affected the design of the circulating-water system and made

for considerable civil engineering construction at Portishead. Four culverts are driven through rock out to a dredged channel in the estuary. These culverts connect to three 45-ft. dia. pump pits 79-ft. deep in the turbine house, each pit being associated with two turbo-alternator sets. The culverts, which are concrete-lined, are each about one-third of a mile in length. The invert levels are at — 37.5 Ordnance datum in order to ensure that the circulating-water pump suctions are "drowned" at the lowest tide conditions. Circulating-water conditions in the Severn Estuary necessitate reversal of flow characteristics, and a manifold system of pipework in the bottom of each pit permits the selection of any culvert for inlet or discharge. The valves for this operation are remotely-controlled hydraulically; the power station requires some 18-million gallons of cooling-water per hour to be taken from the Severn Estuary. The water passes through the culverts from the dredged channel to the screen house, and here, each culvert is intersected by a 21-ft. dia. 70-ft. deep screen shaft which contains two 72-in. wide vertical band-screens fitted with variable-speed drives. From here, the screened water passes to the pump pits and via the manifold pipework to the four circulating-water pumps which are located at the bottom of each pump pit, and driven by four 460 h.p. motors at — 30-ft. level ordnance datum through long vertical shafts and deliver the water through the condensers. The position of the condensers on the — 11-ft. ordnance datum-level floor is such that they give maximum advantage to the siphonic action of the return water to the culverts under low-water conditions. Consequent on the decision to make a section of the station suitable for burning either coal or oil, further civil engineering works were necessary to accommodate (below ground level) two circular steel oil-storage tanks of 9,200 and 13,200 tons capacity, together with an oil transfer pump house. Other civil engineering work comprises the rectangular treated water tank which has a capacity of 500,000 gal. This tank, the top of which is at 85-ft. ordnance datum and approximately level with the ground, forms the foundation for the water-treatment plant house which covers nearly half the tank. The other half is available for additional water-treatment plant if required.

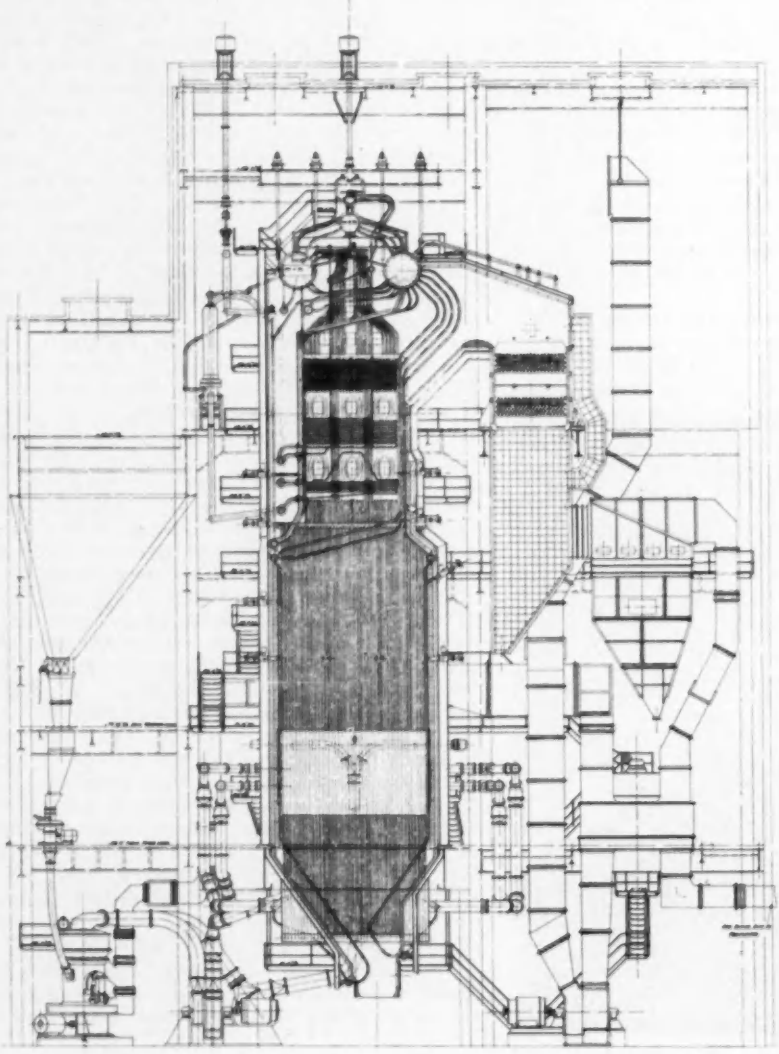


Fig. 2. Outline arrangement of one of the twelve 300,000 lb./hr. boiler units which were supplied by Mitchell Engineering Limited. These boilers have a stop-valve pressure of 950 lb./sq. in. and final temperature of 925 deg. F.

Coal-handling plant

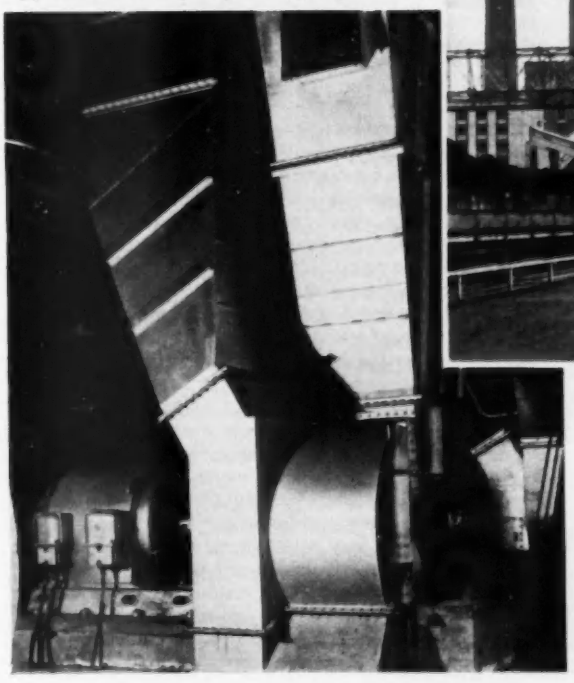
Seaborne coal supplies are off-loaded at the Portishead Dock from colliers of 500-700-tons capacity, while rail-borne coal is off-loaded by wagon tipplers and fed to the conveyor system; also, lorried coal is delivered direct to the working coal store situated on the south side of the station and having a storage capacity of 60,000-ton. The bunker associated with each boiler has a capacity of 450-ton, making the total bunkerage for the eight coal-fired boilers (Nos. 1-8) of 3-600-ton. On the quay-side are two telpher-type unloaders which grab from the boats and discharge the coal via a weigh-hopper recorder on to No. 1 belt, from which the coal can be delivered to either the station bunkers, the working coal store, or divided in any desired proportion to either. A travelling telpher type transporter of 260-ton/hr. capacity spans the working coal store, and distributes the coal into stock, and also reclaims it as necessary back on to No. 1 conveyor. The coaling system is designed for 400-tons/hr. capacity, and incorporates weighing equipment so that by direct weighing or by "differences," the distribution of the incoming coal can be recorded. At two points on the system, magnetic separators are installed to extract any ferrous tramp-iron from the coal.

The coal-unloaders, transporter, and wagon tipplers were supplied by Strachan & Henshaw Limited, and the coal conveyors by Spencer (Melksham) Limited.

Vulcan-Sinclair Fluidrive of the traction type is extensively used in the coal-handling plant for the driving of the Strachan & Henshaw wagon marshallers and tipplers, also the Spencer Melksham conveyors. For the wagon marshallers there are two size 16.25 and two size 12.75 fluid couplings transmitting 25 h.p. at 965 r.p.m. and 7½ h.p. at 950 r.p.m. respectively; two size 20 fluid couplings for the wagon tipplers transmit 30 h.p. at 730 r.p.m. For the conveyor drives there are 16 fluid couplings ranging from size 14.5 rated at 10 h.p. at 940 r.p.m. to size 20 at 60 h.p. at 985 r.p.m. In each case, the smooth acceleration and the light load start to the motor are main reasons for using Fluidrive in these drives, where the starting torque is considerably higher than the running torque. In the case of the wagon-marshallers and tipplers the ability to limit the torque transmitted to a predetermined safe value is an added advantage.

Boiler plant

The boiler house is designed for, and accommodates, a single row of twelve 300,000 lb./hr. boilers, which were supplied by Mitchell Engineering Limited. The first eight boilers are pulverised-fuel-fired, while the remaining (Nos. 9-12) boilers are installed for oil-firing, but designed to facilitate conversion to pulverised-fuel-firing if required. The steam conditions at the superheater outlet are 950 lb./sq. in. and 925 deg. F., with an economiser feed temperature of 385 deg. F. The boilers, each of which have a heating surface of 7,200 sq. ft., and a furnace heating surface of 5,710 sq. ft., have radiant combustion chambers, with the walls completely water-cooled by means of Lopulco close-pitched tubes. Each unit is supported from the main building structure, and is so arranged that all the expansion takes place vertically downwards. It is of interest to note that Mitchell Engineering Limited had previously installed 12 stoker-fired boiler units for the "A" station: eight of which have an m.c.r. of 162,500 lb./hr., and four of 250,000 lb./hr.; all boilers operating with a superheater outlet pressure of 325 lb./sq. in., and a steam temperature of 825 deg. F. In addition, three Mitchell oil-fired boiler



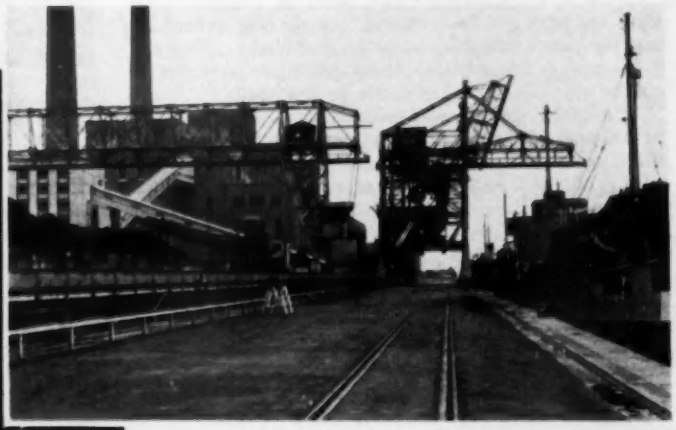


Fig. 4 (above). Coaling wharf showing telpher unloaders, 260 ton/hr. travelling telpher-type transporter, No. 1 coal conveyor, and part of coal storage area.

Fig. 3 (left). One of the Howden forced-draught fans (there being two per boiler), and driven by Laurence, Scott N-S variable-speed motors of 125/10 h.p. at 1,040/403 r.p.m.

units, each of 25,000 lb./hr. capacity at 250 lb./sq. in. saturated steam, have been installed for oil pipeline heating; oil-tank heating, etc. Thus, Mitchell Engineering Limited have installed 27 boiler units at Portishead during the past 25 years.

The boilers in the "B" station are provided with "Greens" Premier Diamond Type 12 economisers, supplied by E. Green & Son Ltd., Wakefield. The economisers are designed on the contra-flow system, flue gases flowing downwards, and feed-water upwards, provision being made for the gases to by-pass the economiser when the units are starting up, or are operating under light load conditions. Each economiser has a heating surface of 17,718 sq. ft. Two air-preheaters of the rotary regenerative type, supplied by James Howden & Co. Ltd., are installed per boiler; each of these Howden-Ljungstrom air-preheaters having a total heating surface of 40,000 sq. ft., and designed to reduce the flue gas gemperature from 615 deg. F., to 295 deg. F., while preheating the combustion air from 90 deg. F. to 503 deg. F. The heating surface is fitted in containers for easy removal or replacement through the sector doors. In addition, James Howden & Co. Ltd., supplied one HK8-design preheater for each of the three auxiliary (25,000 lb./hr.) boilers. The heating surface per preheater in the case of these small units being 2,530 sq. ft., and the flue gas temperature is reduced from 630 deg. F. to 330 deg. F., while preheating the combustion air from 80 deg. F. to 438 deg. F. These preheaters (for the auxiliary boilers) are designed to suit oil-firing conditions, and they are the first "package" design to be installed in this country. The "package" preheater, in standard sizes, is manufactured and erected complete in the Howden works, and only requires to be fixed on prepared foundations, the ducting bolted on and the motor wired-up to be ready for use. Flue gas by-passes are not installed, but facilities are provided to control the element temperature at low load.

The boiler drums were manufactured and supplied by Thomas Firth & John Brown Limited, and comprise front and rear steam drums—which are 54-in. internal dia., 3¼-in. thick, and have an overall length of 30-ft. 6-in., and the steam receiver drums which are 30-in. internal dia., 1⅞-in. thick, and 24-ft. 6-in. long. The combustion equipment for boilers Nos. 1-8 comprises three p.f. mills per boiler—these mills being of the Lopulco type LM 13, supplied by International Combustion Limited. The capacity of each mill is 10-tons/hr. and each mill is driven by a 90 h.p., 1,480 r.p.m. motor, supplied by Laurence, Scott & Electromotors Limited. The mill exhauster fans (three per boiler) were supplied by James Howden & Co. Ltd.—each fan being designed for a volume of 16,000 cu. ft./min. at 28-in. w.g. and at a temperature of 155 deg. F. These fans are driven by Laurence, Scott variable-speed motors, of 155/45 h.p., at 1,470/960 r.p.m. There are 12 p.f. burners per boiler, also supplied by International Combustion Limited, each burner having a capacity of 2,600/4,400 lb./hr.

The "MeLeSco" superheaters, manufactured by The Superheater Co. Ltd., are of the horizontal self-draining type, and designed to give a final steam temperature, automatically controlled at 925 deg. F. and 950 lb./sq. in. from a boiler rating of 240,000 lb./hr. Superheat control over this range is achieved by two "MeLeSco" non-contact type desuperheaters, interposed between the primary and secondary superheaters. The steam temperature controller actuates air-operated relays which control the movement of pneumatic power cylinders linked to the desuperheater butterfly control valves. The superheater is divided into a two-stage primary and a secondary section. The saturated steam enters the primary inlet header from the steam receiver by way of 20 saturated inlet tubes. Steam then flows down through the two stages of the primary superheater

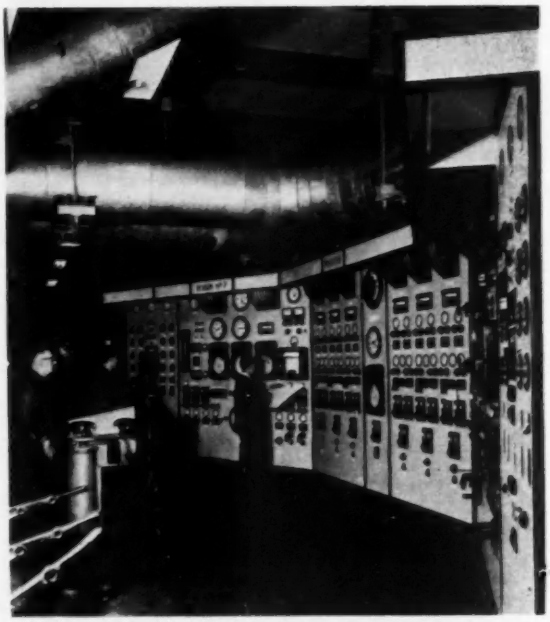


Fig. 5. Control panels and (in centre) master control panel covering the operation of a pair of boilers—viz., Nos. 7 & 8 coal-fired units. The control equipment and panels were supplied by Bailey Meters & Controls Limited.

into the primary outlet header. From this header it passes, via the desuperheaters and their by-passes, to the secondary inlet-header situated at the bottom of the secondary superheater. The direction of steam flow is upwards through the secondary superheater to the outlet header. The primary superheater elements are supported direct from the primary inlet header, with each alternate leg slung by rods from the boiler structure. The secondary elements are carried direct from the primary elements by means of heat-resisting steel slip spacers. The total superheater surface per boiler is 15,490 sq. ft. To assist the operator during pressure raising and on-load steaming, "MeLeSco" supervisory apparatus has been installed. This comprises 24 permanent thermocouples disposed about the superheater, measuring primary outlet and secondary inlet metal temperatures also secondary outlet steam temperatures. A "MeLeSco" sequence switch provides an arrangement whereby these 24 thermocouples may be indicated and recorded in two predetermined groups of 15 on a Sunvic electronic recorder. In addition, it is possible to manually select any individual thermocouple for continuous recording.

A complete system of electrically-operated fully-sequenced soot-blowing equipment is installed on the

main boilers, the steam supply being drawn from the secondary superheater headers. The blowers (supplied by Clyde Blowers Limited, for boilers Nos. 1-8, and by Hopkinsons Limited, for boilers Nos. 9-12), are arranged to operate in the direction of the gas-flow, and are so mounted that they can be removed for examination and repairs while the boiler is on load. Cooling air for the blowers is provided by an air scoop situated in the delivery side of each of the forced-draught fans.

Draught plant

The draught plant for each boiler comprises two forced-draught and two-induced draught fans situated at basement-level, and the twin air-preheaters plus the mechanical grit-arrestors and electrostatic-precipitators. In the event of the loss of one of the above items, as an emergency condition 60 per cent. of boiler m.c.r. can be carried. Both the forced-draught and induced-draught fans are driven by induction regulator controlled variable-speed a.c. motors. The 24 F.D. and 24 I.D. fans were all supplied by James Howden & Co. Ltd. The F.D. units each have a capacity of 56,300 cu. ft./min., at 10.44-in. w.g. and 80 deg. F., and are driven by variable-speed (1,040/403 r.p.m.) motors, each of 125/10 h.p., and supplied by Laurence, Scott & Electromotors Limited. The I.D. fans have a volume of 87,000 cu. ft./min. at 12.76-in. w.g., at 272 deg. F., and are driven by Laurence, Scott 241/20 h.p. motors at 810/403 r.p.m. The mechanical grit-arrestors on boilers Nos. 1-8 (two per boiler) are of the Valmont " S " type, and supplied by Prat Daniel Limited, the hopper capacity per boiler for these grit-arrestors being 3,200 cu. ft.

The flue gases from the coal-fired boilers, after passing through the mechanical grit-collectors, are subsequently treated in Sturtevant electrostatic precipitators—there being one precipitator to each boiler. Each precipitator is designed to give a collecting efficiency of 96.5 per cent. with the boiler operating at m.c.r., but efficiencies in excess of this have been obtained on test. The precipitators are of the vertical-tube type, and comprise a number of banks of hexagonal tubes, each fitted with a central high-tension discharge electrode. The gases entering the precipitators pass downwards to the lower ends of the tubes and turn upwards into the tubes where ionisation takes place, the dust particles being driven to the tube walls and the clean gases passing on by way of the induced-draught fans and the outlet flue system, which includes outlet control dampers, to the chimneys. The tubular dust-collecting electrodes are rapped at pre-determined intervals by electric vibrators controlled by time switches, the dust falling into hoppers below, for subsequent disposal. Each precipitator is divided into two equal and separate compartments, so that in emergency, one half can be isolated electrically and from the gases, the whole load being taken by the other half at reduced efficiency. Each precipitator is equipped with a high-tension transforming and rectifying unit consisting of a high-ratio step-up transformer, a Sturtevant mechanical rectifier, a voltage controller and a low-tension control panel ; two complete units occupy a single housing situated between each pair of precipitators. The high-tension units are interconnected on the output side, so that either set may be shut down for routine cleaning and maintenance, whilst running the two plants for short periods on the other.

Oil-fuel installation

Oil supplies are delivered by sea to Portishead Dock in tankers which are equipped with off-loading pumps whose delivery is connected to the station permanent 16-in. dia. off-loading pipeline through flexible hoses on the wharf. The plant is designed for an off-loading rate of 600-tons/hr. of heavy fuel oil having a viscosity of 6,000 sec. Redwood No. 1 at 100 deg. F. This off-loading pipeline delivers to either of two welded-steel storage tanks located on the " A " station site, and erected within concrete bunds. Oil is drawn from the tanks by means of transfer pumps which deliver to an oil supply ring-main in the boiler house at a controlled pressure. The whole of the oil pipework system and storage tanks, pumps, etc., are steam trace heated and lagged to maintain this oil at a pumpable viscosity (at a temperature of 140 deg. F. approx.). From the boiler house ring-main, oil passes through pumping and heating units which raise

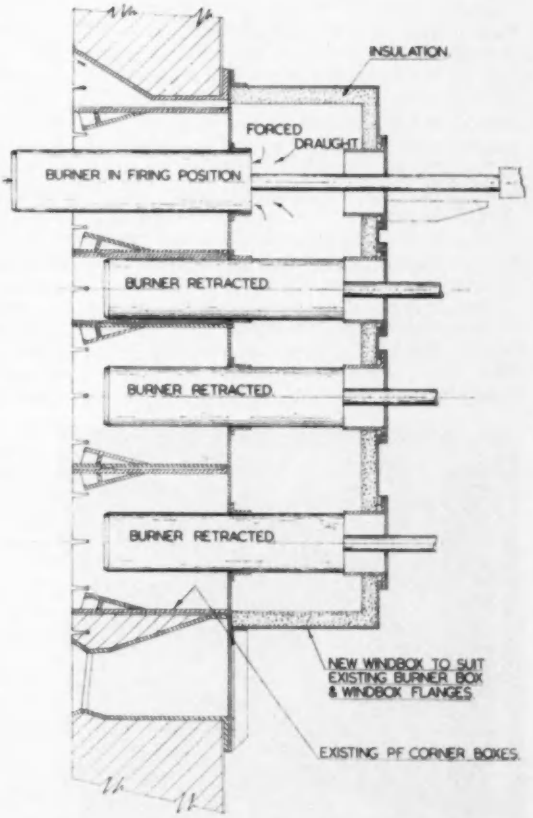


Fig. 6. Section through corner of boiler furnace showing facilities for total shut-off of air on retracted oil burners.

the oil temperature and pressure to the conditions necessary for efficient atomisation at the main oil-burners.

The whole of the fuel oil burning plant (boilers 9-12) was supplied by Fuel Firing Limited, Woodley, Reading, Berks. The availability of the oil-fired boilers from the time of commissioning to the present is stated to have

averaged 96 per cent., the day-to-day efficiency averages 85.5 per cent., and it appears that, at no time has there been any complaint of acid smut or smoke emission. In adapting these four boilers to oil-firing, the contract terms of reference were—that an absolute minimum of modification should be carried out on the existing boiler plant; that the conversion from coal-firing to oil-firing and vice-versa should be carried out in one month; and that the capital cost should be at a minimum. Early in the technical discussions on the conversion it was

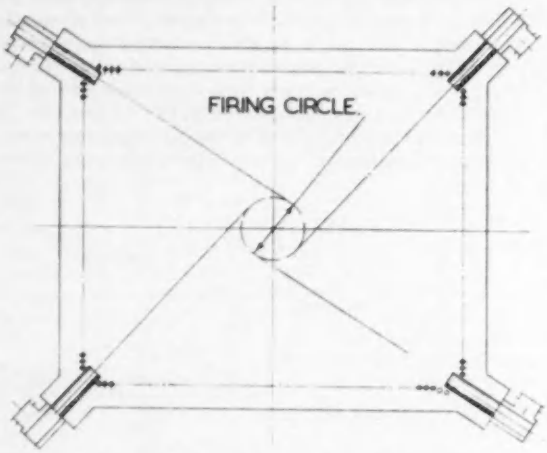


Fig. 7. Diagram showing angle at which oil-burners are set in boiler combustion chamber.

decided that boilers Nos. 1-8 (which were already firing on coal) should be left on coal, and that only Nos. 9-12, (then under construction) should be equipped with oil-firing plant. Accordingly, no precipitators were installed with the four units concerned, and the oil-burners themselves were arranged to be mounted on the flange of the main pulverised-fuel burner boxes while, at the same time, the oil plant control gear was incorporated as an extension of the existing boiler control panel in place of the pulverised-fuel plant controls. The pumping and heating plant is conventional, in that fuel is taken through dual suction strainers to positive displacement-type pumps delivering fuel oil at 450-lb./sq. in. to steam fuel-oil heaters mounted in banks, from which heated fuel oil is supplied to twin discharge filters, whence the oil is circulated round individual ring mains to each boiler. An interesting point on the fuel temperature control is the installation of a viscosity controller, and it is believed that this is the first time that such equipment has been installed on an oil fuel plant. While the fuel oil is delivered at a nominal viscosity this may vary, for various reasons, when temperature control to give the required burning efficiency no longer applies. The provision of a viscosity controller ensures that the fuel oil, regardless of the viscosity at which it is delivered to the storage tanks, is supplied to the burners at the specified value, the necessary heat input on the heaters being thereby looked after automatically.

The fuel oil burners were not only specially-designed for coal to oil conversions, but are the outcome of many months' field research on load-carrying burners, which was carried out with the co-operation of the C.E.G.B. North-West, Merseyside, and North Wales Region. Fuel Firing Limited were permitted to install prototype load-carrying burners on a 90,000-lb./hr. boiler at Wallasey Power Station, and the burners installed at Portishead "B" are the outcome of the research work carried out on this boiler. Fuel Firing Limited already had the unique experience of firing heavy fuels in power station boiler furnaces, in that—many tests were carried out on both the Earley and Bath power stations on the fuel oil burners

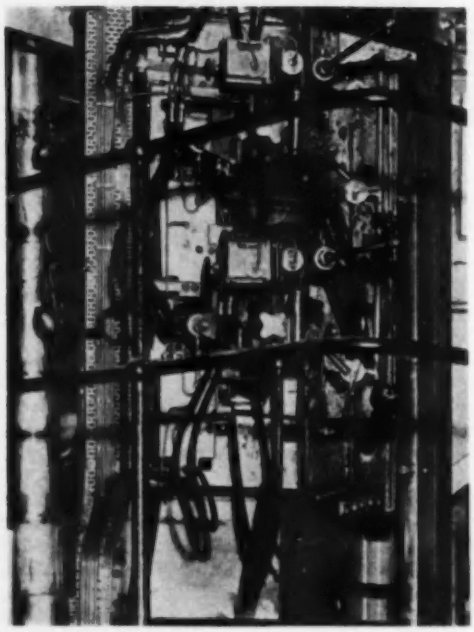


Fig. 8 (left). Close-up view of two of the four Fuel Firing Ltd. oil burners at one corner of the furnace.

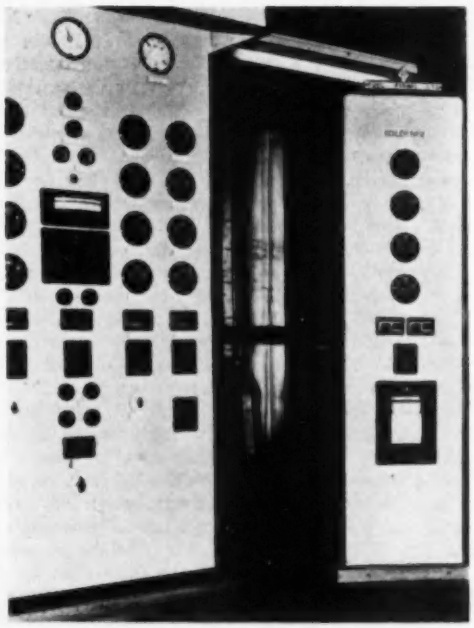


Fig. 9 (right). Individual control of each oil burner is provided on a main control panel, while the separate panel controls the superimposed burners mounted higher in the furnace.

incorporated in the now well-known Type FF1 initiators. The prototype oil-fuel burners first installed at Wallasey were designed in the light of five years' experience on the initiator burner heads. There are many important features on the burners installed at Portishead "B," the first of which is shown in Fig. 6, which is an elevation through one of the corner boxes, from which it will be seen that all the air for combustion is directed through the burner itself. It will also be seen from this diagram that it is a relatively simple matter to remove the whole of the new windboxes containing the burners in a single lift, leaving the burner-box flange free to take the pulverised-fuel burners. When any one burner is taken out of commission, it is automatically retracted, whereupon not only is some protection afforded from the radiant heat of other burners in commission, but—and perhaps, more important—all air to that burner is completely shut off. This means that combustion efficiency on all other burners firing can be maintained at the optimum value without any risk of dilution and the production of SO_3 due to extraneous air. This is borne out by the fact that, since the first of the oil-fired boilers was commissioned, there has been no sign of acid corrosion and there have been no complaints in connection with either smoke or acid smut emission at the stack. The arrangement of the burners in the furnace is shown in Fig. 7, from which it will be seen that, having taken up the existing burner box flanges, the burners in the corners are firing at the tangent to the imaginary circle as would apply in pulverised-fuel-firing. The high turbulence of the oil-burners does not depend on turbulence produced by tangential firing and, in spite of the relatively close proximity of the flame to the furnace walls adjacent to the shallow angle, the flames do not actually touch the wall and, to date, there appears to have been no evidence of furnace-wall erosion. The design of the burners is somewhat special; all the air for combustion first enters the main burner tube, after which it is divided into primary, secondary and tertiary air proportions, all of which are individually adjustable on setting to work since the relative quantities are highly critical from the point of view of achieving satisfactory combustion. Once set, no further adjustment is necessary. The major proportion of the air for combustion is the secondary air, which is compelled to pass through a number of polished stainless-steel curved blades arranged symmetrically round the centre-line of the burner. The oil supply to the burner is conventional, in that it is supplied at 450-lb. pressure, through a return-flow type of sprayer tube supplying oil through an atomiser of a gas-turbine type, which gives the best possible atomisation obtainable at the viscosity employed. The actuation of the burners themselves is unusual in that they are not only fully-automatic from the point of view of combustion control, but are completely automatic and remote-operated when being put into, and taken out of, commission. This part of the equipment incorporates all the features of the corresponding parts of the type FF1 initiators. Oil supply and shut-off valves are controlled by a simple mechanical means on the burners going into the firing position, while the patented air-purge valve gear is similarly actuated and is arranged so that it is mechanically impossible for the fuel oil and purge medium systems to be interconnected.

The burners are automatically ignited by the now familiar patented type FFY, low-voltage, high-heat release ignitor, which is automatically retracted on flame being established. Both the burner and separate ignitor insertion and retraction are achieved by pneumatic drive cylinders taking compressed-air from the station system. Safeguards are provided by Fuel Firing Limited's own flame monitoring equipment, one set of which is mounted on each burner. This is so arranged that, in the event of flame failure on any one burner, that burner is automatically retracted, when the oil supply is automatically turned off as described above. The same equipment also gives lamp indication on the main control panel as to the conditions prevailing upon any burner at any time, and the main feature of this part of the burner is that the electronic flame viewing equipment is not affected by the light from any other burner in the furnace. A close-up of two of the four burners arranged in one corner is shown in Fig. 8. Individual control of each burner is provided on the main control panel, a view of which is shown in Fig. 9, and this also shows the separate panel for the four superimposed burners mounted higher in the furnace to give additional superheat control. As originally installed, four burners were placed in each corner of the furnace and, in view of experience on other oil-firing installations, it was decided to make no special provision for obtaining the full superheat temperature. There is, therefore, no false refractory bottom installed although, at the outset, plastic refractory was applied between the furnace tubes local to the burners. Under these conditions the superheat temperature was only just attained but gave no margin for control by the attemporator. On Nos. 10, 11 and 12 boilers, therefore, four burners were installed for superimposed firing higher up in the furnace, with a view to giving higher superheat on which control by the attemporator can be provided.

The boiler mountings, turbine-valves, pipe-valves, etc., were supplied by Hopkinsons Limited, and they comprise:—torsion-bar safety-valves, safety-valve silencers, Hopkinson Ferranti valves, parallel-slide valves, electric valve controls, water gauges, automatic isolating valves, uniflow valves, etc.

Automatic control equipment

The automatic control for each boiler unit was supplied by Bailey Meters & Controls Limited, and is based on the regulation of total combustion air quantity proportional to the boiler load and co-ordinated adjustment of fuel feed to the mills irrespective of the calorific value of the fuel and of furnace draught, so that between 100 per cent. and 60 per cent. of maximum continuous rating the output of steam is controlled automatically. A master controller connected to and actuated by the pressure in the steam-receiver, transmits impulses to relays which in turn regulate the compressed-air supply to the power cylinders, which, by suitable linkage, regulate the motor speed control gear on fans and fuel feeders.

The system is arranged so that under normal operating conditions each boiler may be controlled automatically as an independent unit, subject only to a master pressure control, common to each pair of boilers, and to a control unit sensitive to the steam flow from each separate boiler. The arrangement incorporates automatic means of reducing the mill feeder output in the event of partial or total choking of the mill, and reinstating normal fuel flow

when such a fuel supply blockage is eliminated.

The Bailey automatic control of the oil-fired boilers (Nos. 9-12) is governed by the master pressure controller initiated by the superheat steam outlet pressure. This pressure is converted into a pneumatic signal (5-25 lb./sq. in. range) proportional to the variation in steam pressure from the desired value, which in turn varies the fuel oil input to the boiler and the combustion-air requirements.

For fuel-control, the master pneumatic signal is taken via a fuel ratio relay to a fuel-oil automatic manual station, and thence to a control drive operating the induction regulator, which in turn varies the speed of the oil recirculating pump. An increase of pump speed decreases the fuel-oil pressure at the burners and vice versa. The ratio relay is provided to adjust the fuel signal, depending upon the number of burners in operation.

Measurement of steam flow by means of a primary element in the secondary superheater outlet is used as a measure of heat input and fuel consumed. Combustion air flow is also measured at the f.d. fan inlet duct. This is totalised and recorded on the boiler meter, together with steam flow and for optimum firing conditions the pens are maintained together. Any deviation between the steam and air flow pens creates an air signal which is taken to modify the master signal and accordingly the air input to the burner windbox by adjustment of the f.d. fans. This modified master signal is taken to the f.d. auto-manual selector valves and also via an air ratio relay to the burner modulated vane-control auto-manual selector valves. The signal to the f.d. fans is at the same time taken to the burner windbox damper control drives, and the fans and dampers are so arranged that for a variation of control signal from 25-14-lb./sq. in. the f.d. fans are taken down to their minimum speed and for a further reduction of control signals the windbox dampers close to reduce the air to the burners to the required turn-down. Burner modulating vane-control auto-manual stations are provided for each tier of burners, the signal positioning the vanes to the required setting for the load demand.

The induced-draught fans are controlled by the furnace-pressure controller, operating from a tapping point in the furnace wall. The pneumatic signal generated by any deviation from the setpoint is used to modify the master signal, and adjust the l.d. fans to maintain desired furnace pressure.

Steam temperature control is by means of recirculating dampers operated by an air signal from the temperature controller having a sensing point in the left and right-hand secondary superheater outlets. The temperature controller signal is also modified by the total air-flow signal used as an anticipatory signal of boiler load.

Fuel oil pump pressure is maintained by the use of a Bourdon type pressure controller, operating from a sensing point in the pump delivery. The air signal generated by any deviation from setpoint is used to reposition an induction regulator control drive, and so adjust pump speed and delivery pressure.

Ash-handling plant

The ash and dust-handling plant was supplied by John Thompson Industrial Constructions Limited.

The clinker from the wet-ash hopper below the boiler furnaces is removed by a high-pressure sluicing system to swirl pits in the ash plant pump house which is located centrally at the rear of the station. Dust from the hoppers of the economisers and dust-extraction equipment is removed pneumatically by the use of high-pressure water ejectors discharging direct into the ash sluiceways. High-pressure ash pumps are used to deliver the ash mixture from the swirl pits to distant concrete settling ponds which are designed for continuous drainage, the filtered water being handled by return water pumps to a reservoir located in the ash plant pump house. High-pressure pumps connected to this reservoir supply the water for sluiceway jets and ejectors. The layout thus provides a complete water recirculating system. Duplicate settling ponds are provided, one being emptied of drained ash by means of mobile equipment and lorries, while the adjacent pond is in commission. The ash removed from the settling pits is transported by lorry to distant ash disposal grounds, situated east of the dock.

Turbine plant

The six 65-MW turbo-alternators which, together with their associated condensing and feed-heating plant were supplied by Metropolitan-Vickers Electrical Co. Ltd. (now A.E.I. Manchester Limited), are arranged in pairs in " line-ahead " fashion, having steam-end to steam-end, with the circulating-water pump pits between sets.

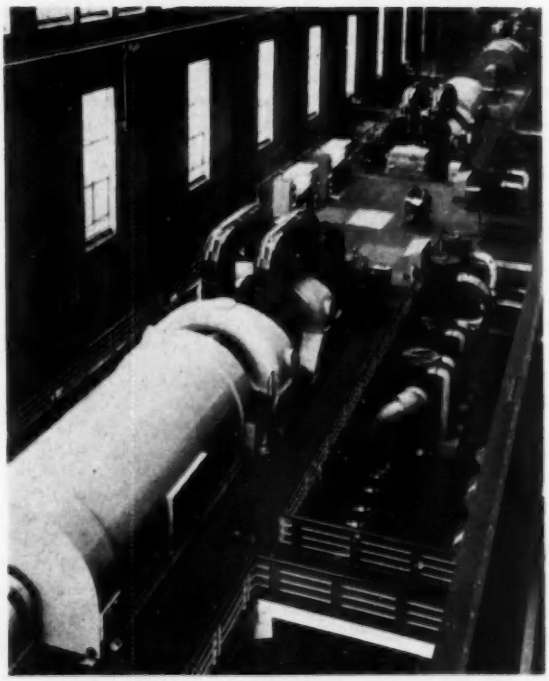


Fig. 10. The six 65-MW turbo-alternator sets are arranged in pairs in " line-ahead " fashion with steam-end to steam-end.

Designed steam conditions are 900 lb./sq. in. and 900 deg. F. at the turbine-stop-valve, with 28.9 in. vacuum, and a final feed temperature of 385 deg. F.

The turbines are two-cylinder units:—the high- and low-pressure turbine rotors are rigidly coupled together, and the cylinders are provided with annular steam belts

at the various extraction points to enable steam to be drawn from the complete periphery instead of from localised areas to preserve thermal balance. Inter-stage drainage is provided where necessary to collect and lead condensed steam to heater belt or to the exhaust chamber. The rotors are mounted on a bearing at each end of the shaft with a third bearing interposed between the high-pressure and low-pressure glands, water-sealed at all speeds. Emergency stop and governor valves of the balanced-pressure type are provided for each turbo-set, the emergency valves being operated automatically by duplicate emergency overspeed governors on the main turbine shaft—set to operate at 3,300 r.p.m. The emergency valves may also be tripped instantly by hand. Speed regulation is effected by a centrifugal governor operating the governor valves through an oil relay system. Hand- and motor-operated speed control gear enables the turbine speed to be raised or lowered by 5 per cent. above or below normal while at " no load." In the event of steam pressure to the turbine falling below 90 per cent. of normal, pressure-operated unloading gear reduces the steam demand of the turbine. This condition could arise through failure of the ignition or other combustion trouble at the boilers. If pressure continues to fall, the throttle steam flow is reduced by 10 per cent. of the " full load " flow by the time the pressure has fallen to 85 per cent. of normal. To provide the turbine operator with a guide to conditions regarding axial expansion, running clearances, and the degree of eccentricity of the rotor, a comprehensive system of supervisory control is installed on a panel adjacent to the high-pressure cylinder of each turbo-set.

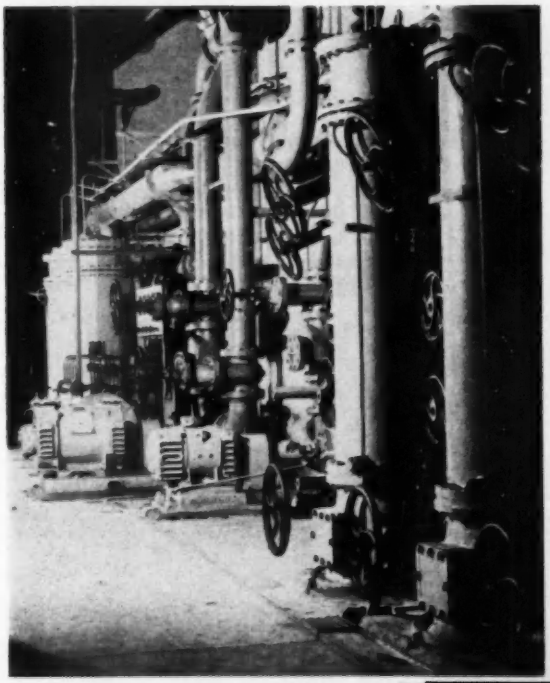


Fig. 11 (above). Cooling equipment for cooling the oil used in the bearings and control mechanism of the turbo-alternator sets.

Each turbine exhausts to a single horizontal condenser, which has a cooling surface of 58,600 sq. ft. and is split vertically so that either half can be opened up for on-load cleaning. Because of serious trouble with graphite corrosion that has been experienced in that part of the country, a special protective treatment has been given to the manifolds and condenser water-boxes, the latter being electrically insulated from the condenser tube-plates. There are two three-stage air-ejectors with surface inter-coolers, and one quick-start air-ejector for each turbine. The three-stage units are condensate-cooled, and each operates at a steam pressure of 500 lb./sq. in. and 1,400 lb./hr., while the quick-start ejector is supplied with steam from the auxiliary steam manifold at 900 lb./sq. in., and discharges directly into the atmospheric exhaust pipe.

Two 100 per cent. duty two-stage extraction pumps, located on 11 ft. O/D level floor in the pump pit, are driven through vertical shafts by motors mounted on + 30 ft. O/D level floor. These a.c. motors are of 140 h.p., at 965 r.p.m., 3,300 volts, and each pump, when working against a head of 295 ft., passes condensate at the rate of 9,100 lb./min. The feed-heating train consists of four surface-heaters and one direct-contact de-aerator heater. Condensate is pumped from the condenser at 81.8 deg. F. by either extraction pump, and is fed through air-ejector, drain-cooler and two low-pressure heaters and gland-heater to the high-level deaerator heater. From here, it drops straight down to the boiler feed-pump suction main and pumped through the two high-pressure heaters and then to the boilers.

Associated with each pair of turbo-alternators and

Fig. 12 (right). The 650,000 lb./hr. boiler feed pumps were supplied by Sulzer Bros. (London) Ltd., five pumps serving each pair of turbo-sets and four boilers.

group of four boilers there are three 100 per cent. duty electrically-driven feed pumps, and two 50 per cent. duty steam turbine driven pumps; all these pumps were supplied by Sulzer Bros. (London) Ltd. Each electrically-driven pump is capable of delivering feedwater at a rate of 650,000 lb./hr. at 1,230 lb./sq. in., and serves two boilers, while the steam-turbine-driven pumps cut in automatically as a temporary standby at reduced feed delivery pressure. The centrally-positioned electrically-driven pump acts as a standby for each pair of boilers, and is started-up by hand.

Each turbine drives a 65-MW 11,800 volt hydrogen-cooled alternator. For alternators Nos. 1-4, the hydrogen pressure is 0.5 lb./sq. in., while for Nos. 5 and 6 it is as high as 15 lb./sq. in. The gas is cooled by circulating distilled water through four heat-exchangers incorporated in the stator frame of each alternator. To prevent excessive leakage of hydrogen between the rotor shafts and the stator bearing end shields, oil seals are fitted on the inner bearing covers. The oil-seal supply is drawn from a compartment in the main oil tank by a pump of 25-gal./min. capacity and delivered via an oil-cooler to the seals. Hydrogen pressure is maintained automatically, and the hydrogen proportion is continually and automatically analysed. The hydrogen scavenging during prolonged shut down is carried out by CO_2 displacement.

Each alternator is solidly coupled by four 1.25 sq. in. cables per phase, to a 72-kVA generator transformer having a no-load voltage ratio of 11.8/141.6-kV with a voltage range through on-load tap-changing equipment for a nominal secondary voltage of 132-kV $\pm$ 10 per cent. over 14 equal taps. Each transformer is of the ON/OFF type with natural cooling up to 50 per cent. full load. The high-voltage side is connected to the Grid switching station. Facilities are provided to tap the leads to the generator transformer to connect to the unit transformer, thus providing a source of starting supply for the generating station in the event of a complete shut down of the "A" station, from which starting supplies are normally obtained. The generator transformers and the unit transformers are sited in outdoor cells along the east wall of the turbine house. Starting and common auxiliaries supplies are obtained from three 7.5-kVA 33/3.3 kV delta/star connected transformers fed from the 33-kV main busbar system on the "A" station. These transformers are of the ON type with off-load $\pm$ 2½ per cent. and + 5 per cent. tap-change. Each feeds a separate 3.3-kV station distribution board, emergency inter-connection facilities being provided between the various boards throughout the station. In addition to controlling the larger common auxiliaries such as ash pumps, re-circulating pumps, standby boiler feed pumps, and coal and ash circuits, the three station boards provide supplies to each 3.3-kV unit board for starting purposes. Each 3.3 kV unit board controls the larger auxiliaries of its associated boiler/turbo-alternator set, together with one outgoing circuit to the 415-V unit board. The 415-V unit board controls in turn the supplies to the turbo-alternator auxiliary board, transformer auxiliary board, boiler auxiliary board, general service pumps, precipitators, and mill group boards.

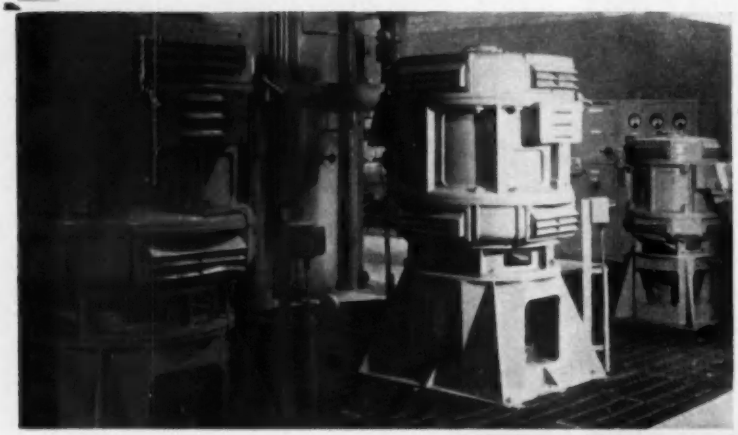
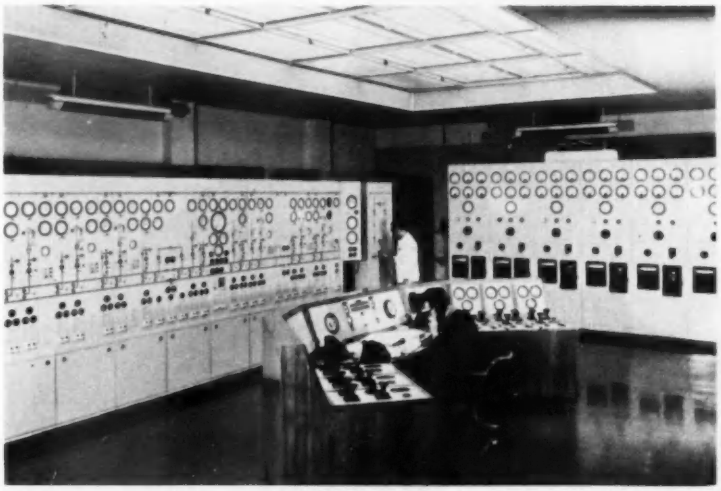


Fig. 13 (above). Motors driving the Drysdale circulating-water pumps, 18 million gal./hr. of water are required for cooling purposes.

Fig. 14 (right). No. 5 turbo-alternator control panel. Each 65-MW set has its individual control panel.

Water-treatment plant

The water-treatment plant, supplied by The Permutit Co. Ltd., is designed to deal with a normal flow of 6,000-gal. of water from the Bristol City of Chevely supply. It consists of a "Precipitator" cold lime process water-softening plant for reducing



The station main control room with the generator instruments panel on the right.

hardness, two vertical pressure-type sand-filters for clarifying the effluent from the "Precipitator" and a fully-automatic ion exchange water-softener for removing residual hardness. The "Precipitator," which operates on the sludge-blanket system, is claimed to give better results, occupies less space than conventional sedimentation tanks, and uses less chemicals. The de-sludging and flushing of the "Precipitator" is automatically controlled. The two filters are each 6-ft. 6-in. dia. and each consists of a pressure-vessel containing a bed of specially-graded sand. After filtering a run, when the head loss across the filter becomes unacceptable, the filter is shut down and cleaned by air scouring and backwashing. The 5-ft. dia. fully-automatic ion exchange softener is self-regenerating. When hardness in the water is detected by a Permutit automatic hardness tester, regeneration is automatically initiated and carried through all stages; the softener is then returned to service.

To mark the completion of this, the Portishead "B" power station, a "civic day" was held on Friday, June 10th, when the station was visited by Lord Lieutenant of Somerset, Lord Hylton, the High Sheriff of the County, the Lord Mayor of Bristol, the M.P.s of that city, and a number of members and senior officials of the C.E.G.B. and other distinguished visitors.

STANDARDS ENGINEERS' CONFERENCE

THE sixth conference of engineers responsible for standards, was held on May 11th, in London.

At the morning session, the chairman, Mr. R. E. Mills (H. M. Hobson Limited; chairman of the Institution of Production Engineers' Standards Committee) introduced Mr. Lewis Wright (past-chairman of the British Productivity Council and Chairman of the T.U.C. Production Committee), who gave the opening address. Mr. Wright recalled that 3,000 British Standards were in operation today, but he thought that at least 30,000 ought to be in use. Progress was required not only in increasing the number of engineering standards, but improvement was necessary in industrial communications. A greater effort should be made to standardise technical terms. Before introducing the second item on the agenda, the chairman noted that, due to limited accommodation, some applications for attendance at the conference had had to be refused, and he apologised to those concerned. Mr. Mills then introduced Mr. N. A. McNeill (chairman of the Council of the Engineering Equipment Users' Association, and chief engineer of Unilever Limited), who gave a talk entitled "Problems Related to the Use of British Standards in Company Standards Operation." He said that the responsibility for promoting greater use of British Standards rested largely with the British Standards Institution to see that documents were precise in their terms for application and simple to interpret. The manufacturer also had to give more publicity to standards and their relation to their proprietary products. In the ensuing discussion, some speakers referred to the apparent lack of cognisance of the views of users when drafting British Standards, and one speaker deplored the time taken to prepare some standards. The final item in the morning discussion "The Place of Standards in Production and Quality Control," was introduced by Mr. I. R. Smith (chief inspector, Bristol Aircraft Limited). To maintain quality, he said, it was first necessary to set the standard that the manufacturer wished to achieve and these standards should be applied at the prototype stage of design. The first item of the afternoon session concerned proposals for an association of those concerned with standards. Mr. H. A. R. Binney (director, British Standards Institution) reported that the panel which had been formed to consider the project had suggested that the most suitable and economical scheme would be to arrange for those who were interested to become special associates, on a personal basis, of the B.S.I. The B.S.I. would extend its services of information about the application of standards and would provide a base for the organisation of national and regional meetings throughout the year. This proposal was agreed to at the conference, and it was also agreed that a subscription of one guinea would be used to finance the administration of these activities. The membership and subscription would be on an individual basis, and would, of course, be quite distinct from the normal subscription paid by firms to finance the B.S.I.'s work as a whole. Application forms for membership were available at the conference, and it was agreed that an inaugural meeting should be held in London on July 8th, when detailed plans would be considered. Standards engineers unable to attend the conference and who wish to take advantage of these new facilities can obtain application forms from the British Standards Institution, 2, Park Street, London, W.1. The final item on the agenda concerned the inch-metric issue in international standards, in particular means of promoting interchangeability of inch and metric sizes.

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Phosphate conditioning of boiler water is well established as the most satisfactory method of preventing scale deposits in all types of boilers. Scale cannot form when a reserve of phosphate is present in boiler water. Phosphate conditioning is indispensable at high pressures, and leads to such improvements at low pressures that it is generally preferred to other treatments.

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RECENT Equipment AND Accessories

Steam-accumulator or standby boiler

A method of increasing the efficiency of boilers in applications where there is a fluctuating demand for steam, has been developed by British Boiler Accessories Limited. This involves the use of a Lancashire boiler as a steam-accumulator or standby boiler, which, by storing surplus steam produced during periods of small demands and releasing it during peak load periods enables the boiler to operate steadily at an even rate corresponding to the average steam consumption throughout the day. Steam is stored in the form of hot water, and the system operates on the variable-pressure principle. The water is contained in a closed vessel which is partly filled, and the water temperature raised to 212 deg. F. by mixing with live steam. When this temperature is reached, a small amount of steam is formed which, as it is unable to escape, increases the atmospheric pressure within the vessel. The temperature is then further increased by mixing the water with more steam and when this reaches the boiling point corresponding to the increased pressure, a further small amount of steam is produced which again increases the pressure, the process being continually repeated. When a valve at the top of the vessel is opened to release the steam for use, the pressure within the vessel is reduced, and as the water has a high temperature in relation to the new pressure, it commences to boil, a certain amount being converted into steam. This takes out a quantity of the latent heat from the remaining water, the temperature of which consequently drops until the balance between pressure and temperature is restored. B.B.A. have developed an external charging device for fitting to standby Lancashire boilers, and which operates in a manner similar to an injector. Live steam from the high-pressure main is injected through a nozzle, creating a strong suction effect which draws water from the standby boiler and injects it into a venturi tube where the steam and water are thoroughly mixed, the steam being condensed. The heated water flows to the upper part of the standby boiler creating a strong circulation on the water content whereby cool water is drawn from the lower part of the standby boiler, heated in the charging device and returned to the upper part. The accumulator/standby boiler is thus charged by gradually raising the temperature and pressure of its contents. Discharge is controlled by a reducing-valve, and charging can be controlled either manually or by a valve operated by the high pressure main, in which case the accumulator works automatically. (*British Boiler Accessories Limited, 62-3, Fenchurch Street, London, E.C.3.*)

Fig. 1. Example of Lancashire boiler/steam accumulator dual capacity installation for an industrial plant. (British Boiler Accessories Limited.)

Compressed air pipeline filter

Vokes Limited have recently introduced a new type of compressed-air filter for ¼-in., ⅜-in. and ½-in. pipelines, and with alternative elements giving two degrees of performance. The standard general-purpose element is the VAF.57, suitable for applications where removal of water or oil mist and grit is required, but where the concentrations are average. The alternative element, the " D " Pak, is for applications where oil or water mist removal is of primary importance and a high degree of purity is essential. Other types of element are available for special duties. All element assemblies are interchangeable. A die-cast, light alloy, head-casting houses the filter element, which can be removed by unscrewing one nut. A ribbed clamp-ring mating with a thread on the head is employed to fit a transparent plastic bowl which is available in two different capacities. The standard unit is capable of operation at pressures up to 150 lb./sq. in. Units for operation at pressures in excess of this, and up to 250 lb./sq. in., are supplied with metal bowls. (*Vokes Ltd., Henley Park, Guildford, Surrey.*)

Fully-automatic pressure-jet oil burners

K.S. Burners Limited have introduced a new range of fully-automatic oil-burners designed for use with gas oil of 35 to 45 seconds viscosity Redwood No. 1. They can be supplied for flange mounting, or for pedestal mounting, and are claimed to be suitable for firing all types of boilers and oil-fired space heaters. Five burners are included in the new range, with capacities from 50,000 B.Th.U. to 1,100,000 B.Th.U./hr. Any type of control can be supplied with these burners, although the makers say they have carried out tests with a photo-electronic control which provides fully-automatic programming with pre- and post-purge periods, instantaneous flame-failure and re-cycling sequence, and this control can be supplied fitted to the burner, pre-wired and tested to provide a package unit. (*K. S. Burners Limited, 121, Crescent Lane, London, S.W.4.*)

In-line viscosity controller

We were recently invited to see a demonstration of an in-line viscosity controller, manufactured by the Industrial Instrument Division of S. Smith & Sons (England) Limited. This was developed following a request by the Mobil Oil Co. Ltd., and the equipment now available has been designed to provide continuous control of the oil-blending

Fig. 2. A "Smith's" viscosity controller in use at Mobil Oil Company's Ellesmere Port, Cheshire, Ocean Terminal. [S. Smith & Sons (England) Ltd., Industrial Instrument Div.]

process to such fine limits that an oil company could guarantee its final product viscosities to within 1 per cent. In operation, by the use of two viscometers, the viscosity of a sample from a pump-line is continuously balanced against the viscosity of a sample prepared in the laboratory. The viscosity of each sample is measured by a rotating cup viscometer, the output torque of which acts upon a balance arm. Both viscometers run in a water-bath, and are driven at the same speed by an electric motor. The laboratory-tested sample in its viscometer is at the temperature of the bath, and the pump-line sample quickly attains that temperature as it passes through the heat-exchanger, which is also immersed in the bath. Although the precise heat of the bath is not important, as the viscosity of each sample is measured at the same temperature, in practice it is increased when dealing with products of high viscosity, in order to reduce torque to a reasonable value. With each viscometer running at the same speed and temperature, if the viscosity of the standard sample is the same as the viscosity of the product under test, the torque exerted by both viscometers will be equal, and the balance arm will be in a state of equilibrium. In the same way, a change in viscosity of the line product will cause the balance arm to move, and in doing so operate a micro-switch or a pneumatic control. Manufacturing tolerances rule out the possibility of the two viscometers having exactly the same gaps between moving and static elements, so an adjustment is provided for the fulcrum of the balance arm. Identical samples are run through the viscometers while adjustment is made to achieve this balance. [*S. Smith & Sons (England) Limited, Industrial Instrument Division, North Circular Road, London, N.W.2.*]

Waterproofing insulated pipelines

F. A. (Membranes) Limited have introduced a new waterproofing material known as Oppanol sheeting. This is a new black poly-isobutylene thermoplastic sheeting of 1 mm. thickness for waterproofing insulated pipelines. Supplied in rolls 45-ft. long by 39-in. wide, it can be cut to shape with a knife or scissors. Wrapped around the insulated pipe with 2-in. edge and 3-in. end laps, the overlaps are welded together by a brushed-on solvent and pressed

Fig. 3. Example of main steam piping, weather-proofed with Oppanol. [F. A. (Membranes) Limited.]

down by hand. This operation welds the two thicknesses of sheeting together giving a lap which is as water and vapour-proof as the sheeting itself. Oppanol does not, it is claimed, age or rot, and is proof against acid attack and corrosion. Once installed, no maintenance is required; the saving over a period of years, therefore, can be considerable. It is easy to handle, and rapid of application, as compared with other materials employed for water-proofing insulated pipes. It withstands temperatures from − 30 to + 70 deg. C., and can be painted to any colour required. [*F. A. (Membranes) Limited, St. Helens, Lancs.*]

Heavy-duty electric valve actuator

A heavy-duty electric motor for operating butterfly and rotary stem valves, is now available from Honeywell Controls Limited. Known as the "Actionator," it consists of a reversing capacitor-type motor with a

Fig. 4. Stable control of butterfly and rotary stem valves, dampers and louvres or vertical acting slip stem valves is achieved with the rugged fast-acting "Actionator" electric motor. (Honeywell Controls Limited.)

gear train to give the required timing. Various speeds are available ranging from 9.0 sec. to 144 sec. for 180° rotation or full stroke operation. Torque output is up to 200-lb. in., and there is an internal brake to hold the load in any position without "hunting" or "coasting" when the motor is de-energised. Models are available for two-position, floating or proportional control action. Cam-operated micro switches control the extent of motor travel in either direction, and up to four auxiliary switches of the same kind can be incorporated. A retransmitting slide-wire can be substituted in the proportional control model. The "Actionator" components are housed in a die-cast aluminium housing; and the company claim that it will work continuously without loss of efficiency in ambient temperatures as low as 25 deg. F. and high as 150 deg. F. (*Honeywell Controls Limited, Ruislip Road East, Greenford, Middlesex.*)

Butterfly-type control valves

Crosby Valve & Engineering Co. Ltd. have now added to their manufacturing programme the comprehensive range of Mason Neilan butterfly-type control valves. They are available in steel or cast-iron as

standard materials, as wafer-type for mounting directly between pipe flanges, in standard sizes, from 2-in. to 24-in. The valves are normally supplied with air-operated diaphragm-type actuators for use with all types of pneumatic controls, but can also be supplied for lever, handwheel, chainwheel or electric motor operation. Other features are that the valves can readily be changed on site

Fig. 5. Mason-Neilan butterfly control valve. (Crosby Valve & Engineering Co. Ltd.)

from air to open, or air to close, and from 60°-90° opening. The linkage is arranged so that the maximum possible mechanical advantage is achieved when the torque developed on the shaft by the following medium is at its greatest. The crank is locked on the shaft by a simple shakeproof and foolproof key. On heavy-duty type valves the stuffing-box is readily accessible and studs and bolts are exceptionally heavy. Totally-enclosed outboard, flexible-type roller bearings are used on all sizes. The vane is pinned to the shaft in a manner giving minimum reduction on shaft area and minimising any possible expansion effects. (*Crosby Valve & Engineering Co. Ltd., Ealing Road, Alperton, Wembley, Middlesex.*)

Stop-valves for cold fluids

Hunt & Mitton Limited announce a special adaptation of a standard valve to give a tight shut-off and to isolate the packing from the proximity of very cold fluids. The valve in question is the "F"-type bronze globe pattern hand-wheel-operated stop valve, which has been provided with a special heat-transfer gland, which enables it to obtain heat from the atmosphere, to maintain the gland at a normal temperature. It also gives a very tight shut-off, and has obvious applications in connection with refrigerant liquors and vapours. It can be supplied in sizes from ½ to 3-in., and the materials used in its construction are: bronze body and head; cast-iron handwheel; Nickloy valve seat and block; stainless steel spindle; brass bar gland nut; and Con. bronze heat-transfer gland. (*Hunt & Mitton Limited, Oozells Street North, Birmingham, 1.*)

New squirrel-cage motors

A new range of totally-enclosed, fan-cooled, squirrel-cage motors with Class E insulation, and complying with Draft B.S. A(ELE)1629, has been introduced by The General Electric Co. Ltd. Motors of up to 7½-h.p. at 1,500 r.p.m., and 5-h.p. at 1,000 r.p.m., are immediately available, while sizes up to 40-h.p. will, the company say, be available shortly. These "D" frame machines have a continuous maximum rating in accordance with B.S. 2613 for a temperature rise of 65 deg. C. in ambient temperatures up to 40 deg. C. They are interchangeable with ventilated machines ("C" frames) of the same rating complying with B.S. 2960. (*The General Electric Co. Ltd. of England, Rotating Plant Division, Witton, Birmingham, 6.*)

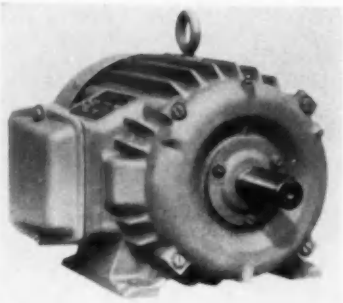


Fig. 6 (above). Example of new squirrel-cage motor. (General Electric Co. Ltd.)

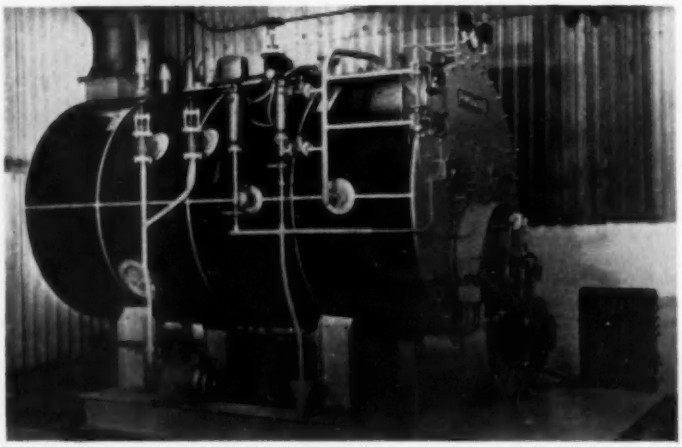
Fig. 7 (below). "Poweraiser" fully-automatic all-welded boiler. (Deepdale Engineering Co. Ltd.)

Tests on all-welded boiler

During tests on a fully-automatic "Poweraiser" boiler, operating at 100-lb./sq. in. and producing 3,000-lb./hr., efficiencies above 80 per cent. were recorded. Of all-welded construction, using Ferromax iron powder electrodes supplied by Quasi-Arc Limited, the "Poweraiser" has been designed and is manufactured by Deepdale Engineering Co. Ltd., Dudley, to Class 1 radiographic standards. The company claim that the boiler is exceptionally quiet in operation and, therefore, particularly suitable for installation in hospitals, laundries, etc. (*Quasi-Arc Limited, 213, Oxford Street, Bilston, Staffs.*)

Rotary discharge valve

A rotary discharge valve designed to provide a continuous and free discharge of dust or fine powders from hoppers or bin outlets is now available, in a very compact form, from Dunford & Elliott Process Engineering Limited. The valve consists of a horizontal body with 8-in. square inlet and outlet flanges between which a 9-in. dia. four-bladed rotor revolves on a longitudinal axis. The rotor is fully-shrouded and a positive seal is obtained between it and the housing by means of renewable hard felt seals recessed into the main body casting. Complete gas and dust tightness is ensured by the stainless-steel or neoprene rubber adjustable sealing and wearing strips which are fitted to the tips of the rotor blades. Compactness has been achieved by mounting the reduction gearbox to form one end cover of the valve body, a design feature which eliminates the



use of couplings or chain drives. The rotor is carried on the drive shaft of the gear unit, the drive being transmitted through a shear pin to prevent damage to the gear-box or to the motor in the event of overloading or jamming of the rotor. The unit is powered by a ¼-h.p. totally-enclosed fan-cooled, continuously-rated squirrel-cage motor which, driving through a triple-reduction gear-box, provides a rotor speed of 12 r.p.m. The valve is manufacturered in cast-iron or stainless-steel, and is available in two sizes: as a single unit having a capacity of 100 cu. ft./hr. or as a duplex unit with double this capacity. (*Dunford & Elliott Process Engineering Limited, Linford Street, London, S.W.8.*)

Lockheed Precision Products Limited, Speke, Liverpool, recently held a private exhibition in London, and which was entitled "How Hydraulics Can Help Your Projects." Hydraulic applications play a vital part in almost every industry, and at this exhibition the company displayed a wide variety of examples of their controls and operating equipment. Lockheed manufacture complete hydraulic systems, several of which were shown in actual or diagrammatic form at the exhibition; typical examples being semi-rotary slaves which represented the most compact form of actuator unit, and this is manufactured in many sizes and types. There were also various examples of Lockheed control cabinets, ratchet drive units and exhibits from the comprehensive range of Lockheed Avery flexible hoses and self-sealing couplings. Another product of the Automotive Group, which was featured, was the Purolator micronic and metal-edge filters. The display of these was confined to hydraulic filters, and comprised a wide range covering varying degrees of filtration and flow rates.

* * *

Belliss & Morcom Limited are now manufacturing under licence, the French M.P.R. rotary compressor. This new development extends their range of compressors into the smaller sizes with what they consider to be the most suitable design for small volume requirements. The range of operation of these rotary compressors is up to 50 lb./sq. in. for single-stage machines and from 50 to 110 lb./sq. in. for two-stage machines, with outputs from 100 to 600 cu. ft./min. in the first instance, which will slightly overlap the lower part of the present range of B. & M. reciprocating compressors. A direct-coupled constant-speed a.c. electric motor is the recommended type of drive.

* * *

Hamworthy Engineering Limited have purchased **Schieldrop & Company,** Stotfield, Beds., one of the leading manufacturers of industrial oil-burning equipment for kilns and furnaces. The Schieldrop range of oil-burning equipment is complementary to the Hamworthy range, and will considerably broaden the base of Hamworthy oil-burning interests. Schieldrop & Company will continue to trade as a separate entity, and **Mr. I. P. Frost** will continue as managing director. Hamworthy's role will be mainly to supply additional technical and financial support to the Schieldrop organisation, so that the two companies will jointly make greater progress in oil-firing technique.

* * *

The Association of Supervising Electrical Engineers announces that **Lord Verulam** is to succeed **Sir Josiah Eccles** as president next October.

The Darlington Insulation Co. Ltd., a member of the Darlington Group of Companies, has been awarded the contract for the heat insulation for the three 860,000 lb./hr. Babcock and Wilcox boilers at the new Uskmouth "B" power station, Newport, Mon. The company has already carried out the insulation of the Uskmouth "A" power station, and this further contract will provide additional work for local labour for approximately 18 months.

* * *

A new, larger edition of **Keith Blackman's** "Heavy Fan Engineering" booklet (Publication No. 25, 24 pages) has now been published, and is available from the Publicity Department, Mill Mead Road, London, N.17. (Telephone: Tottenham 4522, Ext. 310.) This is a fully-illustrated booklet, designed to show the scope of the "Tornado" range of fan engineering equipment in the large and heavy sizes. Individual sections deal with centrifugal and axial-fans, blowers and exhausters, ancillary equipment such as air-heaters, dust exhaust and collecting plant, and metal structure and fabrications. A further section provides a brief survey of the manufacturing facilities available at the three Keith Blackman works at Tottenham and Edmonton, London, and at Arbroath in Scotland.

* * *

A new publication, "No. 1641," issued by **Babcock & Wilcox Limited,** is entitled "Babcock Central Station Boilers." This well-produced brochure of some 92 pages, includes comprehensive and descriptive notes and illustrations of "Babcock" Central Station Boilers of the radiant bi-drum, integral-furnace and C.T.M. types, respectively. The brochure includes numerous sectional outline arrangements of various boilers of these types, with many illustrations of actual installations.

* * *

William Boby & Co. Ltd., Rickmansworth, Herts., have been awarded a contract valued at more than £20,000 by Courtaulds for water-treatment plant to be installed in the extension of their Courtelle plant at their Grimsby factory.

* * *

"Welcome to Turners" is the title of a new publication issued by **Turner Brothers Asbestos Co. Ltd.** This publication describes the company's ramifications and wide range of activities, which cover the asbestos textile, belting and Plastics Reinforcement fields. Copies of the publication may be obtained upon application to the company at P.O. Box No. 40, Rochdale, Lancs.

* * *

Mr. L. B. Pearson, A.M.Inst.F., deputy station superintendent, Tilbury generating station, Eastern Division, C.E.G.B., has been appointed station superintendent.

New "Megger" Insulation and Continuity Tester

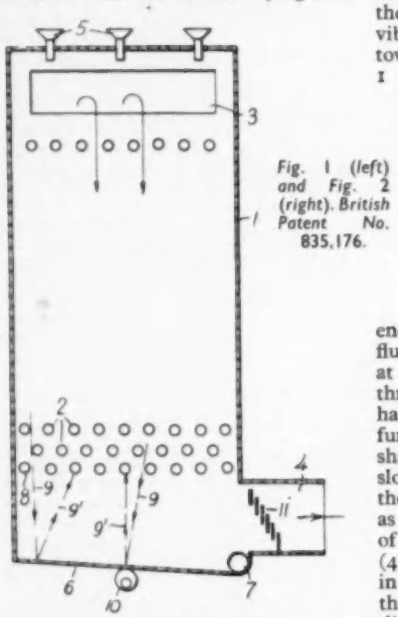
The new Series 3 "Megger" recently introduced by Evershed and Vignoles Limited incorporates many advanced features. These have been made possible by use of new manufacturing techniques and materials, and are the result of an extensive survey to find out exactly what the average user requires. A true ohmmeter movement makes any adjustment before use unnecessary, and simplifies operating procedure so that the instrument, which is calibrated with international markings, may be used anywhere in the world by personnel of all levels of technical training. In addition to the insulation testing range, the instrument now operates over a continuity range from 0-100 ohms with a scale shape which permits readings as low as 0.1 ohm or even fractions of this by interpolation. The continuity testing voltage (4 volts) is obtained from a new and very advanced miniature generator, so that no battery is required, and constant readiness for use is ensured. One of the noticeable benefits is the considerable reduction in effort required to turn the generator handle. This has been achieved by ingenious use of inherent characteristics of the generator and the measuring circuit inputs, by which it was possible to dispense with a separate stabilisation network and thus reduce the load on the generator. A clutchless nylon gear train transmits the handle torque to the generator and provides remarkably smooth and consistent operation under all conditions. It is interesting to note that despite the absence of a separate regulation network, the terminal voltage/handle speed characteristics and the terminal voltage/load characteristics of the new instrument are quite outstanding and meet the most stringent requirements for insulation testers of this type as specified by British and foreign authorities throughout the world. By careful design, it has been possible to house the new instrument in a case of identical shape and size to its predecessor, but manufactured in a stronger, impact resistant material. The change-over from "continuity" to "insulation" ranges is by a slider switch recessed in the side of the instrument. Three ranges of the instrument are available, the 500 volt testing pressure version covering 0-100 megohms and infinity on the insulation range and 0-100 ohms on the continuity range; the 250-volt version 0-50 megohms and infinity and 0-100 ohms; and the 100-volt version 0-20 megohms and infinity and 0-100 ohms. A full description of the new instrument and of the technical design considerations underlying it, is freely available on request from Evershed and Vignoles Limited, Acton Lane Works, Chiswick, London, W.4.

Latest Power Plant Patents

These extracts from British Patent Specifications are reproduced by permission of The Controller of H.M. Stationery Office. (Complete British Specifications can be obtained from the Patent Office, 26, Southampton Buildings, London, W.C.2. Price 3s. 6d. each, both inland and abroad.)

Soot removal device

This invention relates to devices for cleaning heating surfaces of economisers, steam boilers and similar equipment from soot, by means of pig-iron grains bounding against the heating surfaces. These grains may be of various shape and size, and are referred to as " hails " in the following. The dropping hails are able effectively to clean the heating surfaces in substantially all points. However, in a shaft comprising the tubes, the bottom side of the lowest tubes is deprived of the impact of the hails to a great extent, because in this location there are no underlying tube surfaces from which the hails are able to rebound as in case of the remainder of the rows of tubes. One object of the invention is to remove the drawbacks in question and enable a complete cleaning also of the lowermost heating surfaces. Another object of the invention is to enable discharge of the hail from the bottom of the heating plant by simple means requiring only little vertical space. For this purpose, there are mounted below the lowest portion of the heating surfaces one or more rebounding surfaces extending substantially horizontally or only slightly sloping, so that hails dropped from the heating surfaces, and hitting the rebounding surface, rebound from it against the lowest heating surface. The rebounding surface may be constituted by the top of a grate, a perforated plate or the suchlike, or the bottom of the shaft may be suitably arranged to serve this purpose. The hails may be successively conveyed to an outlet in order to prevent collection of hails in great quantities on the bottom which would make the rebounding difficult or impossible. To this end, the bottom wall may be actuated by a vibrator to cause the hails to move towards the outlet. In outline Figs. 1 and 2 an economiser shaft (1) encloses heating surfaces (2). The flue gases enter through an inlet (3) at the top of the shaft and escape through the outlet conduit (4). The hail is supplied through a number of funnels (5). The bottom (6) of the shaft is nearly horizontal or slightly sloping towards the outlet (7). At the same time, the bottom is located as high and close to the lowest row of tubes as permitted by the outlets (4) and (7). Hail leaving the tubes in the direction (9), for example, will thus bounce at the bottom (6) in the directions (9') so as to hit the bottom side of the tubes of row (8), and thereby release soot, cinder, and suchlike which might have stuck at that point. Located below the bottom may be a vibrator (10) which imposes vibrations to the bottom. A grating (11) is provided to prevent the hail from being entrained to the outlet (4) for the flue gases. In the layout according to Fig. 2, a perforated plate or grate (12) is mounted at a relatively small distance from the lowermost row (8) of tubes beneath the latter. The hails jump up from this grate to the lower side of the tubes of the row (8).



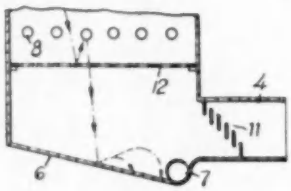


Fig. 1 (left) and Fig. 2 (right). British Patent No. 835,176.

In this case, the bottom (6) of the shaft might be a little more inclined so that the hails roll toward the outlet (7), so that the vibrator may be omitted. Optionally, as an alternative, the bottom may be mounted horizontally, and a scraper or other conveying device may be used to feed the hail toward the outlet (7). *British Patent No.* 835,176 *issued to K. E. Patenter A.B. Complete specification published May* 18*th*, 1960.

Surface condenser

This invention relates to surface condensers for condensing turbine plant. As shown in Fig. 3, the surface condenser comprises a shell (1) with a steam inlet socket (2) at the top, a water-well (20) at the bottom, and lateral outlet sockets (15) for the withdrawal of non-condensible gases. A number of tube blocks (3, 4 and 5) are arranged within the shell at both sides of a vertical plane through the centre line of the condenser shell. The tubes are held by transverse walls (e.g. 21). At their ends the tubes are held in the usual tube heads and open into chambers for the supply and withdrawal of the cooling water. The individual tubes are so arranged that the condensate formed on one tube, when dripping down, impinges on only a small portion, not more than a third of the surface of the next following lower tube. The tube blocks (3, 4 and 5) are arranged symmetrically with respect to the centre-line plane of the condenser shell, so that the two tube-blocks (3), which are nearest to the centre-line plane, are in a V-formation. The next following tube-blocks (4) are substantially parallel to the innermost tube-blocks (3); however, the upper-ends are at a greater distance from one another than the lower ends, so that downwardly tapering interspaces (7 and 8) are formed between adjacent tube blocks. A partition wall (10) or (11) is arranged along the sides of the tube-blocks (3 and 4) respectively, at the side of each block remote from the centre-line. Thus, the steam is guided to move downward through the interspaces between the tube-blocks (3) and between the tube blocks (3 and 4) and to enter the tube-blocks from one side only. The entry of the steam into the tube-blocks

in this way is facilitated by the provision of tube-less pockets (22) in the tube blocks at their sides which face the centre-line plane. Thus, the steam passing downwardly enters the downwardly extending tube blocks substantially over their whole length so that the condensate formed in the upper sections of a tube block will be heated on its way downwards by the incoming steam whereby an undercooling of the condensate is avoided. The partition wall (11) at the rear of each block (4) is extended at its upper-end up to the condenser

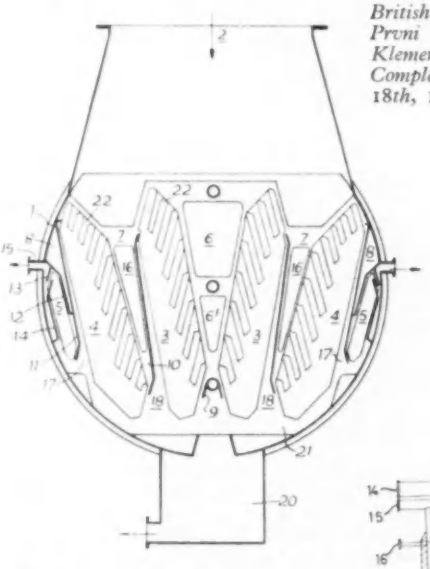
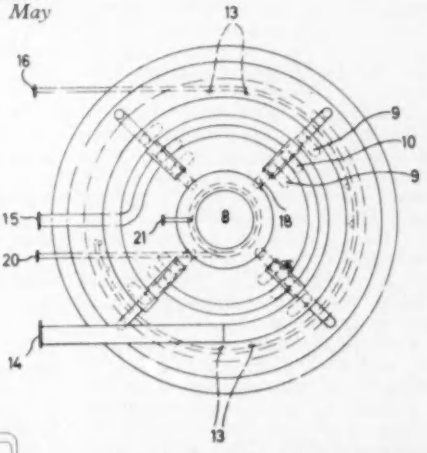
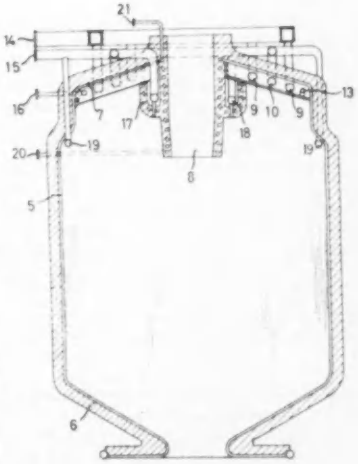


Fig. 3 (left). British Patent No. 835,423.

Fig. 4 (below), Fig. 5 (right) and Fig. 6 (below right). British Patent No. 835,888



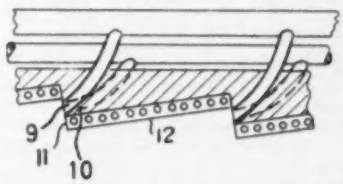


shell, so that the outer tube-blocks (5) are completely screened, and the steam to be condensed has no direct access into the tubes of these blocks. These blocks are arranged in front of the flanged sockets (15) and serve for the undercooling of the non-condensible gas which has to be removed through the sockets (15). Except for the lower inlet part, the tube-blocks (5) are surrounded by guide and baffle plates to impose an upward movement to the non-condensible gases through the tube-block. At one side, the tube-block (5) is bordered by the lower part of the partition wall (11) and then by a guide wall (12); at the opposite side, a guide wall (14) being provided and at the top of a baffle plate (13) is arranged to deflect the gas stream before it reaches the outlet socket (15). In this way a satisfactory cooling of the withdrawn non-condensible gas is ensured. In operation, the steam arriving through the socket (2) follows the paths of the smallest resistance, that is to say, it flows into the V-shape interspace between the blocks (3) and the downwardly tapering interspaces between the blocks (3 and 4) and enters the tube blocks along their whole length. Part of the condensate sweeps past the cooling tubes, another part flows down the partitions (10 and 11) into the spaces (17 and 18) where it drops down into the condensate well and is reheated in this way by steam which is still present in this part of the condenser. The non-condensible gas is caused to enter the under-cooling tube blocks (5) and is eventually withdrawn through the sockets (15).

British Patent No. 835,423 *issued to Prvni Vrnenska Strojirna, Zavody Klementa Gottwalda, Narodni Podnik. Complete specification published May 18th,* 1960.

Vertical combustion chamber

As will be seen in Fig. 4 and Fig. 5, the combustion chamber comprises a substantially cylindrical tube system (5) with a contraction (6) at the lower end. The side-wall tubes (5) at the same time constitute a ceiling or cover (7), through which a substantially cylindrical gas take-off duct (8) projects. Through the annular cover (7) project burner nozzles (9) between each two of which, a secondary air nozzle (10) is arranged. Around the central gas take-off duct (8) is arranged an eversion (17), thus forming a double-wall duct construction of the cover, between the walls of which additional nozzles (18) are provided which serve for injecting air into the chamber through the lower-end of the eversion. The double-wall duct construction is cooled by a tube arrangement having water inlet and outlet (20, 21) respectively. If desired, fuel burners can similarly be arranged between the double walls of the take-off duct. In Fig. 4, further air nozzles (19) are shown which are arranged beneath a stepped increase in diameter of the outer-wall, such nozzles in this example only being shown at one level. As indicated in Fig. 6, the cover in vertical section on a circle about the axis of the chamber is stepped with a saw-like profile which consists of alternate steep and less steep parts (11 and 12) respectively.

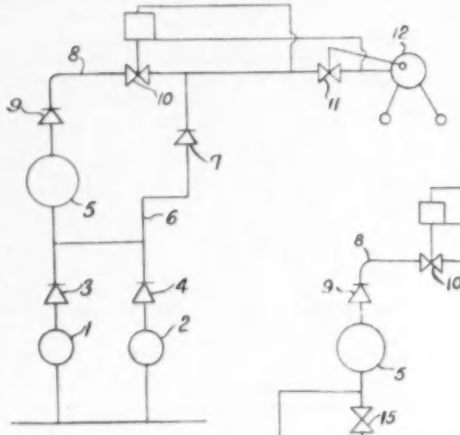


The burners (9) and secondary-air nozzles (10) open through the steep parts (11). Only the less steep parts are provided with cooling tubes. The nozzle arrangement (seen from above) is shown in Fig. 5. The media to be injected are led to the nozzles by ring-shaped pipes (14), (15) and (16), which carry respectively the fuel-air mixture, the secondary-air and the fly-ash to be returned for combustion. There are four rows

of burner nozzles (9), each consisting of two nozzles arranged on the same radial line with the radial lines at 90°, and between the two burner nozzles on each radial line there is one secondary-air nozzle (10). The fly-ash nozzles (13) are arranged in a circle which lies near the cylindrical outer wall (5) of the chamber, being of larger diameter than the circle of the outermost burner nozzles (9). *British Patent No.* 835,888 *issued to Walther & Cie, A.G. Complete specification published May 25th,* 1960.

Boiler feed pump installation

This invention relates to boiler feed pump installations. It is designed to provide boiler feed pump installations incorporating several pumps connected to operate in parallel. Under certain operating conditions, particularly where the boiler pressure varies substantially over the range of boiler load, it is advantageous at certain conditions of load, to operate the pumps in series and at other conditions of load to operate the pumps in parallel. According to this invention the installation includes at least one low-pressure pump, and at least one high-pressure pump, the outlet of the low-pressure pump being connected to the inlet of the high-pressure pump and also by way of a valve to a line leading directly to the associated boiler; the outlet of the high-pressure pump being connected also to the last mentioned line. The outlet of the low-pressure pump may be connected to the inlet of the high-pressure pump by way of a non-return valve. In Figs. 7 and 8, numerals (1 and 2) denote low-pressure pumps adapted to discharge through non-return valves (3 and 4) to a high-pressure pump (5) or to a line (6) by-passing the high-pressure pump (5) and containing a non-return valve (7). The line (6) is connected to a line (8) which is connected to the discharge of the high-pressure pump (5) by a non-return valve (9) and containing an excess pressure valve (10) and a regulator valve (11) sensitive to the level of water in an associated boiler (12). The setting of the excess pressure valve (10) is determined by the pressure difference prevailing across the regulator valve (11). The installation shown in Fig. 8 is exactly similar to that illustrated in Fig. 7, but there is additionally provided a pipe (13) connected to the intake of the high-pressure pump (5) and by-passing the low-pressure pumps (1 and 2), the line (13) containing a non-return valve (14) and a stop-valve (15) is provided on the intake from the low pressure pumps (1 and 2) to the high-pressure pump (5) so that the low-pressure pumps (1 and 2) may be isolated from the high-pressure pump (5). In practice, at low boiler loads, the pressure in the boiler is high and the valve (7) is closed. The discharge from the low-pressure pumps (1 and 2) is then fed by way of the non-return valves (3 and 4) to the high-pressure pump (5) where its pressure is boosted. As the load on the boiler (12) increases, the boiler pressure falls and the pressure in the feed-line (8) falls until it reaches a value equal to the discharge pressure of the low-pressure pumps (1 and 2). A further increase in load on the boiler (12), resulting in a further reduction in the feed pressure, will cause the valve (7) to open so that water flows directly from the low-pressure pumps (1 and 2) into the line (8), by-passing the high-pressure pump (5). In the construction outlined in Fig. 8, when the boiler load is high and the low-pressure pumps (1 and 2) are fed directly to the line (8), the stop-valve (15) may be closed, the high-pressure pump (5) thereupon drawing water directly through the line (13) and the non-return valve (14) to thus function as an additional low-pressure pump running in parallel with the low-pressure pumps (1 and 2). The excess pressure valve (10) throttles the discharge of the high-pressure pump (5) to prevent excessive pressure-drop across the feed regulator (11) when the boiler pressure is low in relation to the feed pump discharge pressure in the line (8). The valves (7 and 9) may be stop-valves, in which case they must be closed or opened manually according to the prevailing operating conditions to provide the desired effect. *British Patent No.* 836,146 *issued to G. & J. Weir Limited. Complete specification published June 1st,* 1960.



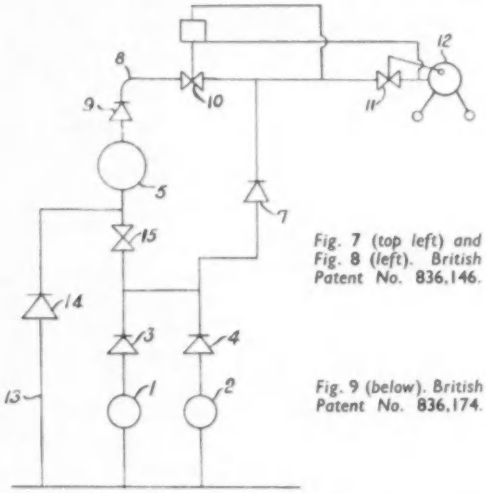
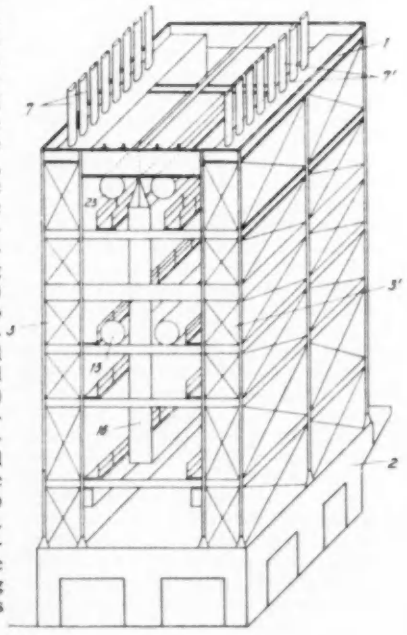


Fig. 7 (top left) and Fig. 8 (left). British Patent No. 836,146.

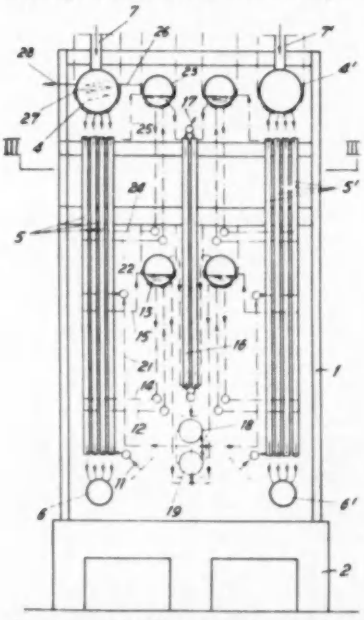
Fig. 9 (below). British Patent No. 836,174.

Steam generator for nuclear power plant

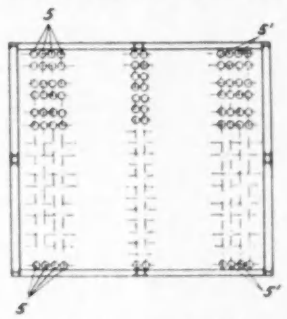
Steam generators of conventional design, in which a hot gas under pressure gives up its heat to apparatus for heating and evaporating water for the production of steam, often present difficult structural problems. This is especially the case in nuclear power



stations in which carbonic acid gas passes out of a reactor at a pressure of the order of about 30 kg. per sq. cm. (2.1 lb./sq. in.) and at a temperature of about 300 to 350 deg. C. When the exchange of heat is effected in a single

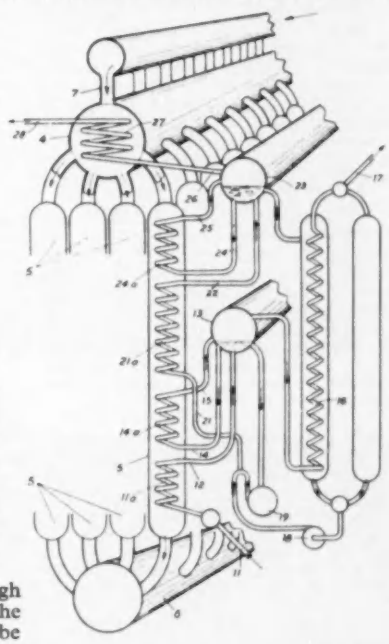


chamber which contains the heating and evaporation apparatus for the cooling water, this single chamber must be closed by very thick metallic sheets which are very costly. These drawbacks are overcome in the battery-type installation which is shown in outline in Figs. 9, 10, 11 and 12. The installation comprises a frame (1) suitably braced and resting on a base (2), the whole being contained in a large sphere in the case of a nuclear power installation. The frame comprises two lateral portions (3 and 3'), each containing a distribution chamber (4 and 4') (see Fig. 10), a battery of tubes or cylinders (5) and (5') and an evacuation chamber (6 and 6'). Into the distribution chamber (4 and 4') pass the supply pipes (7 and 7') which convey the gas under pressure, for example, CO_2, which is to give up its heat by evaporating water; this gas is distributed separately into the interchangeable tubes or cylinders (5 and 5'), and then passes into the collector evacuation chambers (6 and 6'). The tubes will preferably be suspended in the frame (1) from the top by springs. Each of the tubes or cylinders comprises in its lower portion a low pressure zone, and a high-pressure zone in its upper part, the detail of which is outlined in Fig. 12. The water to be heated passes into the tube at its base at (11), is heated in the lower part (11a) of this tube which acts as a preheater, passes out of the tube at point (12), and proceeds to the low-pressure steam and water drum (13),



Figs. 10 (left), 11 (above) and 12 (right). British Patent No. 836,174.

from which the water returns at (14) to the low-pressure evaporator (14a) of the tube. The steam passes out from the evaporator at (15) and flows into the drum (13) whence it passes into the low-pressure superheater (16), which is suspended between the batteries of tubes. Thence, the low pressure steam passes at (17) into the low-pressure turbines. The high pressure pump (19) supplies at (21) the high pressure zone (21a) of the tube which comprises, like the low-pressure zone, a pre-heater from which the water passes out at (22) and is directed into the high-pressure steam and water drum (23) and an evaporator (24a) which receives water from the drum through a pipe (24) and from which steam flows into the drum through a pipe (25). From the drum, the steam passes at (26) to the superheater (27) which is contained in the distribution chamber (4) of the gas under pressure, the steam flowing from the superheater through a pipe (28) to the high-pressure turbines. Hot-water under pressure also passes from the drum (23) to the jacket of the superheater (16), from which it passes to the



recycling pump (18) which returns it through the pipe (21) to the high-pressure preheater and thence back to the drum (23). The hot-water under pressure in the jacket of the superheater (16) serves to superheat the low-pressure steam which passes through the superheater from the drum (13) to the pipe (17). *British Patent No. 836,174 issued to Stein et Roubaix. Complete specification published June 1st, 1960.*

Mr. W. Lionel Fraser, C.M.G., has been appointed the first president of Babcock & Wilcox Limited. **Sir Kenneth Hague** is now chairman of the board, and **Sir Reginald Verdon Smith** deputy-chairman.

* * *

Sheepbridge Equipment Limited, Chesterfield, has announced the appointment of **Mr. H. J. Hall,** a former works manager in the Sheepbridge Engineering Group, as general manager. **Mr. E. G. Scrannage** has been appointed works manager. **Mr. J. H. Lomas** is no longer employed by the group. **Mr. A. Elliott** has taken over the position of chief buyer for the Sheepbridge Eng. Group.

* * *

William Boby & Co. Ltd., water treatment engineers, Rickmansworth, Herts., have been awarded a contract by Courtaulds, valued at several thousand pounds, for a pilot demineralisation plant, for export to U.S.S.R.

Sturtevant Engineering Co. Ltd. have issued two new publications:—No. 3505 "Fans for Mechanical Draught," and No. 3504 "Newgate Dust Collector." These publications supersede Nos. 3502 and 3503, respectively, both of which are now out of print. The publication dealing with Sturtevant fans is a 24-page brochure, describing and illustrating various types of fan, design and construction features, fan output control, fan drives, etc. The second publication, that dealing with the Newgate Dust-Collector, describes and illustrates this unit, which has been developed to enable users of furnaces to comply with the requirements of the Clean Air Act, and to take the fullest advantage of the cheaper low-grade fuels available. Over the range of plant and operating duties for which the "Newgate" Dust Collector is designed, the sustained collecting efficiency ranges between 78 and 85 per cent.

Notes Personal and Industrial

Dr. P. R. Howard, Ph.D., B.Sc. (Eng.), A.M.I.E.E., has been appointed head of the high-voltage laboratories at the Central Electricity Research Laboratories, Leatherhead. As head of the laboratories, Dr. Howard will be assisted by **Mr. D. F. Oakeshott,** B.Sc., A.Inst.P., M.I.E.E., who has been appointed deputy-head.

* * *

C. J. Atkins (sales director) and **Mr. F. W. Goodge** (contracts director) have been appointed joint assistant managing directors, of Keith Blackman Ltd. The following new appointments have also been made. **Mr. F. W. Brown,** commercial manager; **Mr. E. A. Manning,** V. dept. manager; **Mr. R. F. Williamson,** contracts manager and **Mr. P. C. Burden,** chief draughtsman (contracts).

* * *

Mr. John Martin has been appointed to the board of Mather & Platt Limited, as head of the pump department. For the last 10 years Mr. Martin was managing director of Mather & Platt (S.A.) (Pty.) Ltd. with headquarters in Johannesburg, and for 16 years prior to 1949 he was on the staff of the London office of Mather & Platt Limited.

* * *

Mr. J. R. Davies has been appointed sales manager of Crompton Parkinson (Stud Welding) Limited, in succession to **Mr. R. W. Taylor.**

* * *

Humphreys & Glasgow Limited, London, fuel and chemical engineers, announce the election to the Board of the company of **Mr. R. Langford** and **Mr. I. H. Phillipps,** both of whom have, since 1957, been associate directors. Mr. Langford is chief contracts manager and was formerly head of Humphreys & Glasgow's Underground Gasification Department. The company has also announced the election of **Mr. G. Adams** and **Mr. R. J. Withers** as Associate Directors.

* * *

Mr. E. W. A. Richards, F.C.I.S., secretary of Keith Blackman Ltd., London, N.17, has been appointed a director of the company.

* * *

Mr. Ian Cameron, general manager of the Southampton works of John I. Thornycroft & Co. Ltd., has been appointed a director of the company.

* * *

The Cambridge Instrument Co. Ltd. have moved their Nottingham office to new and larger premises at Century Insurance Building, Milton Street, Nottingham (telephone: 42612). The resident engineer in **Mr. H. G. Starling.**

* * *

Mr. C. H. Offord, general manager of the Newhouse (Lanarkshire) factory of Honeywell Controls Limited, has been made a director of the company.

It is with regret that we record the death which occurred recently in Nottingham, at the age of 64, of **Mr. L. F. Jeffrey,** M.Inst.C.E., M.I.Mech.E., M.I.E.E., who, until the end of June, 1958, was divisional controller of the East Midlands Division, C.E.G.B.

* * *

Mr. C. J. George, A.M.I.E.E., has been appointed deputy commercial and development adviser to the Electricity Council, in succession to **Mr. R. Y. Sanders,** who retired from his full-time appointment last October. Mr. George joined the electricity supply industry 25 years ago and received his early practical training with the Brighton Corporation Electricity Undertaking. Following war service, he returned to the Brighton undertaking as development engineer. On nationalisation of the industry he moved from the Brighton and Hove District to become assistant commercial engineer in the Mid-Sussex Sub-Area of the South Eastern Board. In 1952 he joined the British Electricity Authority as senior assistant commercial engineer, and later held managerial appointments with the Central Authority. Since the formation of the Electricity Council he has been principal assistant engineer (development) until his present appointment.

* * *

The Engineering Group of The General Electric Co. Ltd. recently announced the appointment of **Mr. J. L. Orme,** A.M.I.E.E., as deputy chief engineer for the London, Eastern, and Southern Areas. It will be recalled that Mr. E. W. Molesworth was recently appointed chief engineer for the same areas. Mr. Orme joined the head office of the company and later was appointed chief assistant to the manager of Central Stations Department, **Mr. G. H. Mann,** who retired on January 31st last. Although in his new appointment Mr. Orme will be associated with all the engineering activities of the company, his main interest will still be in the electricity supply industry.

* * *

Mr. K. C. Hibbert, M.Inst.F., until recently, station superintendent, Watford power station, has been appointed station superintendent, Peterborough power station.

* * *

Sturtevant Engineering Co. Ltd. have issued a new publication (No. 2304) entitled "Sturtevant Products." This publication supersedes No. 2303, which is now out of print. The publication describes and illustrates the wide range of Sturtevant products including fans, driers and drying systems, dust-collecting systems, gas-cleaning, electrostatic precipitation, high-efficiency cyclones, mechanical dust-collectors, etc. The publication is well illustrated with views of typical installations of Sturtevant plant and equipment.

Mr. R. M. Atkinson has retired from the position of managing director of Sulzer Bros. (London) Ltd., and of Hathorn, Davey & Co. Ltd., and has been appointed chairman of the board of each company. Messrs. **E. H. Stagg, G. W. Heslett,** and **M. W. Zublin** have been appointed joint managing directors of each company.

* * *

Firth Cleveland Pumps Limited, a member of the Firth Cleveland Group, have moved to a new factory at Earl Shilton, about two miles from Markfield, Leicester, where the company has been established for many years. All the company's employees at Markfield will now work at Earl Shilton. In addition, employment will be available for a high proportion of the men and women who become redundant when the previous owners of the Earl Shilton factory ceased production. The move to Earl Shilton will enable the company to establish considerably enlarged machine shops, and carefully sited assembly lines for the wide range of Barnes self-priming and Dickow self-priming pumps, and Firth Cleveland water systems now in production at Markfield.

* * *

W. H. Allen Sons & Co. Ltd., Bedford, have been awarded, subject to the approval of the Ministry of Housing and Local Government, the contract for the main pumphouse machinery for the foul water portion of the new Bristol Drainage Scheme. The plant to be supplied comprises six 33-in. vertical-spindle suspended mixed-flow pumps driven by four Allen constant-speed, and two Laurence, Scott & Electromotors variable-speed a.c. motors. The contract includes the high- and low-voltage control gear and the power transformer.

* * *

Fireye Controls Co. Ltd., 14, Fetter Lane, London, E.C.4, announce that they are now able to supply and install installations of electronic and photoelectric controls for various automation requirements. They can also supply instruments and controls for specialised functions required in industry, such as controls for smoke-density indicators, liquid-level controls, electric timers and high-temperature photoelectric pyrometers. Further details can be obtained from the company at the above address.

* * *

The Central Electricity Generating Board has recently produced a 36-page booklet entitled "Pattern of Power," and which deals with the grid and supergrid systems. The need for a supergrid is discussed, reference is made to the cross-Channel cable, and the difference in the cost of underground cables and overhead lines is explained. The final section of the booklet deals with technical details of the system, sub-station, switchgear and transformer design.

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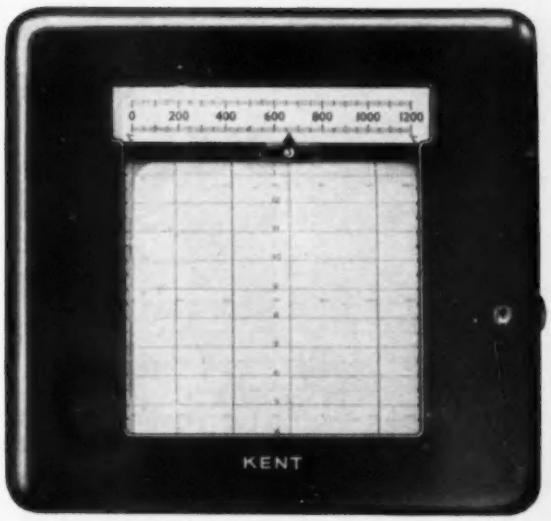

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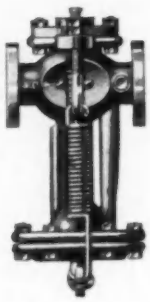

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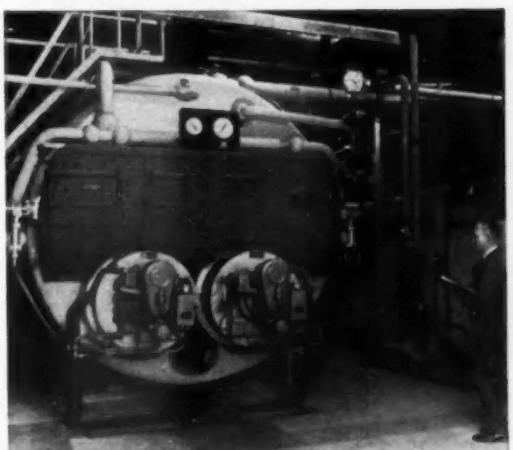

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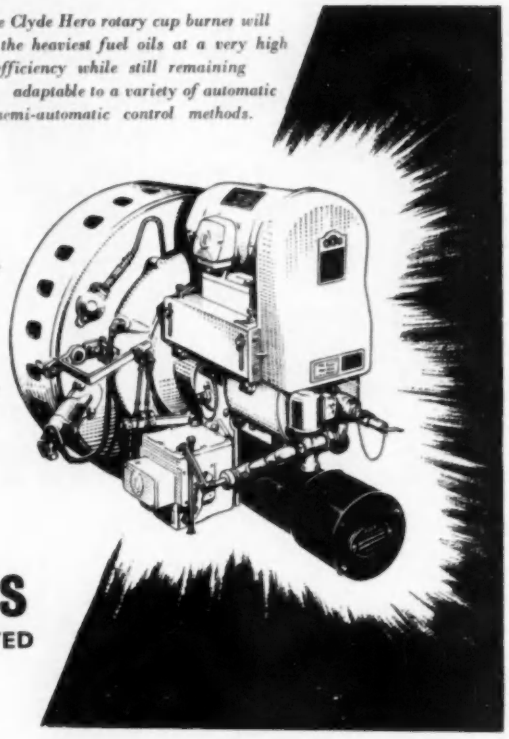

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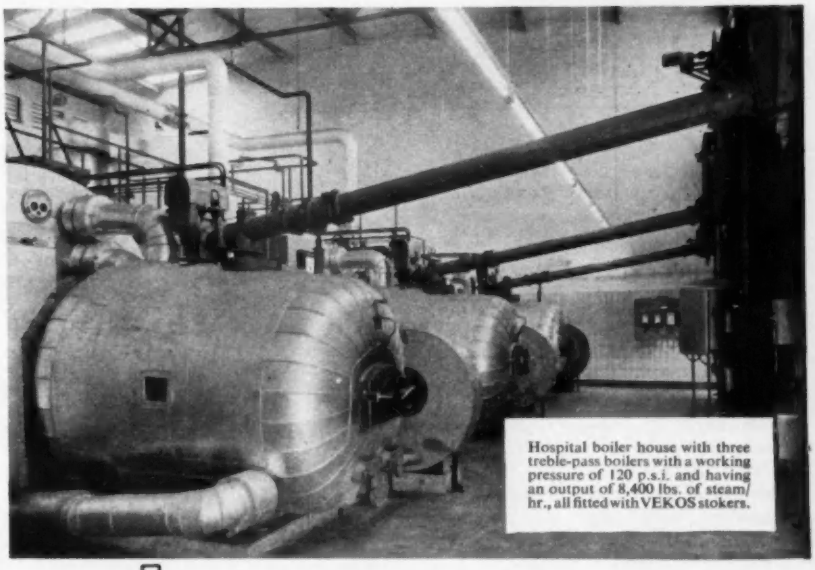

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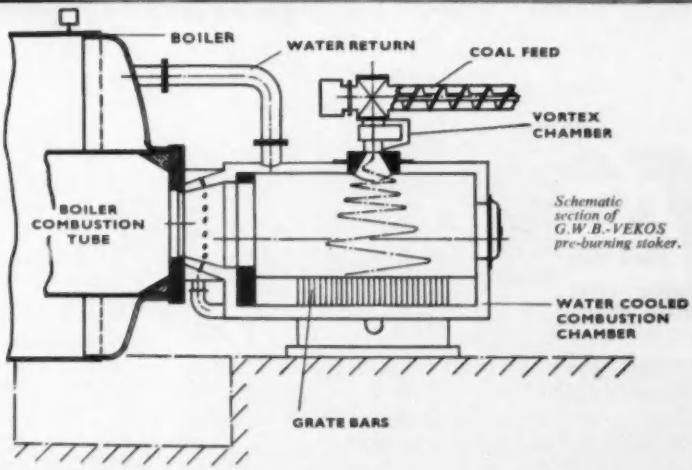

Schematic section of G.W.B.-VEKOS pre-burning stoker.

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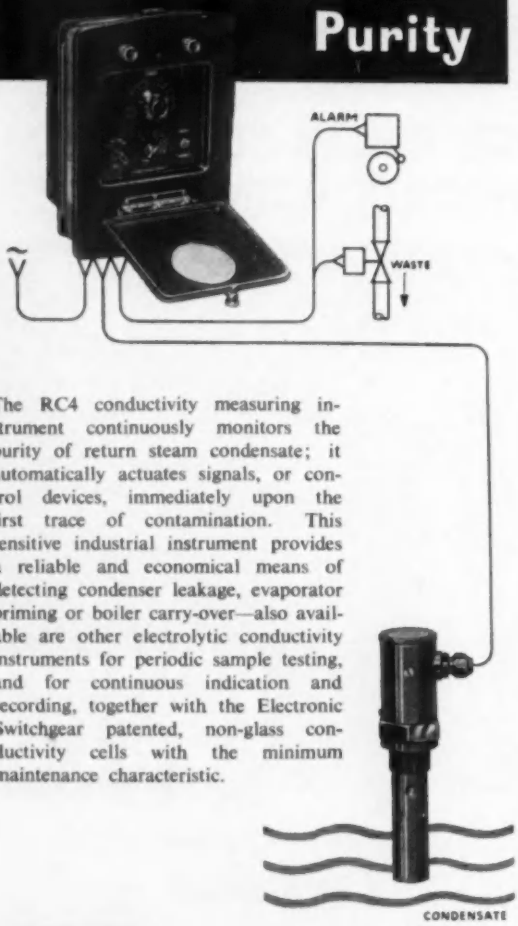

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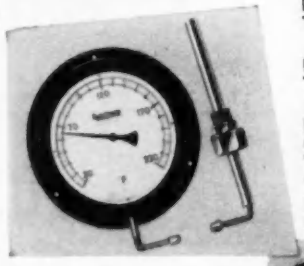

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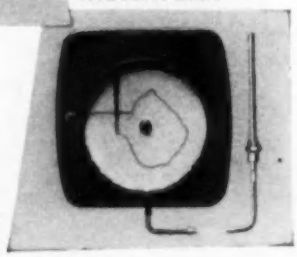

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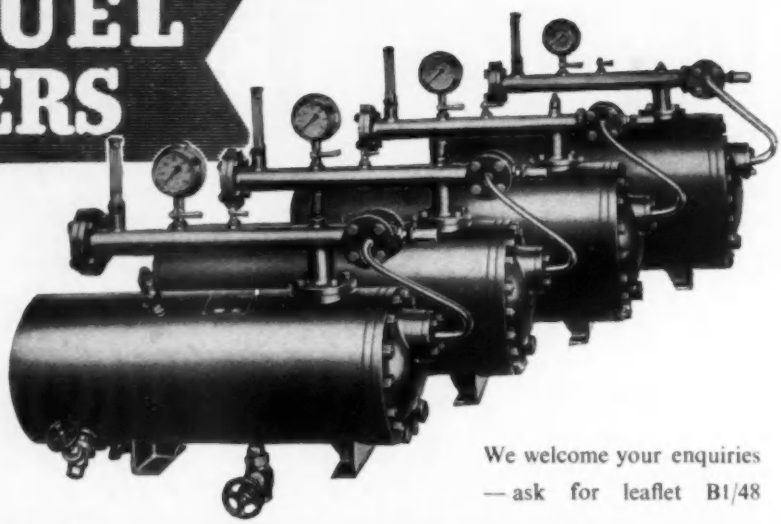

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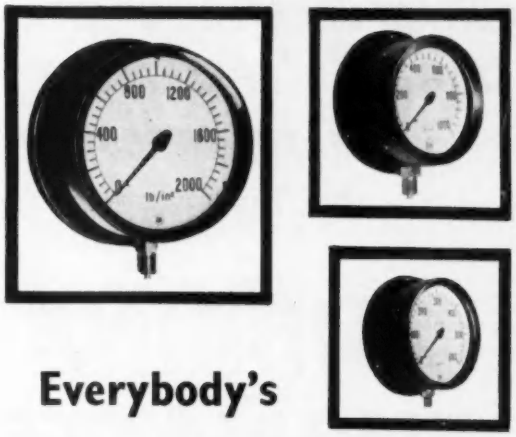

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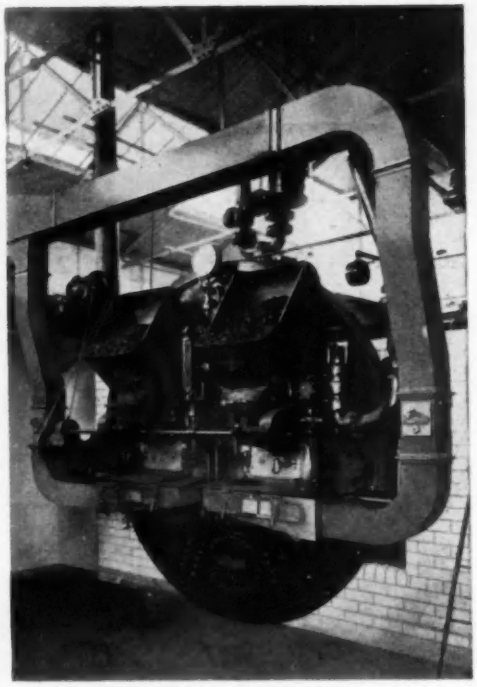

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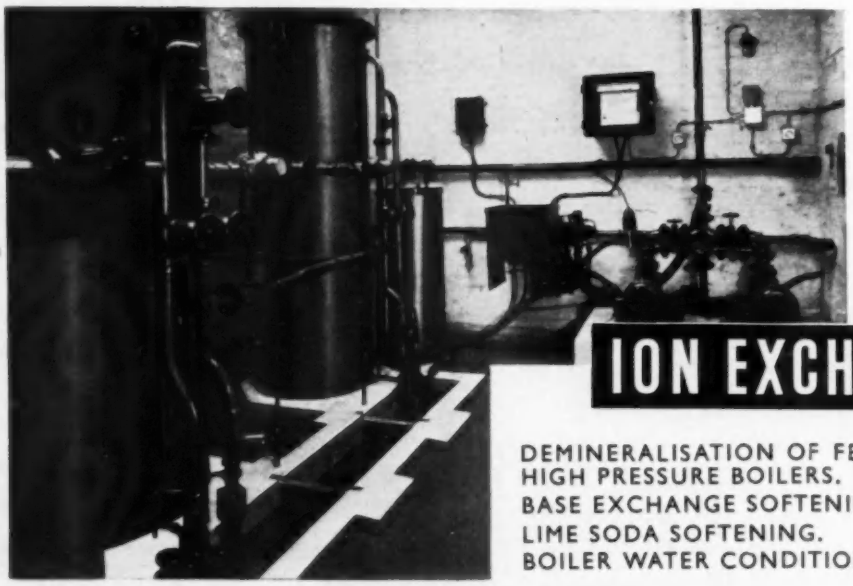

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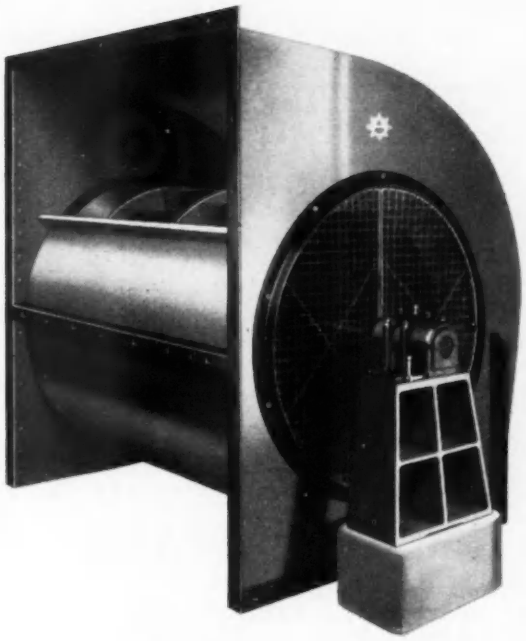

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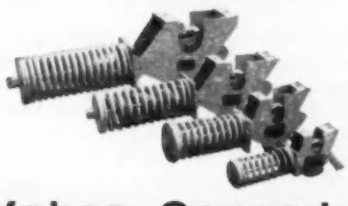

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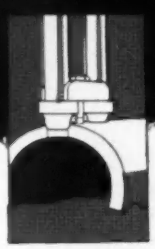

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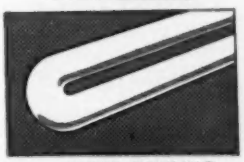

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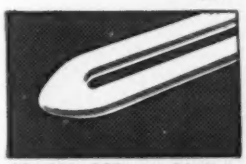

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